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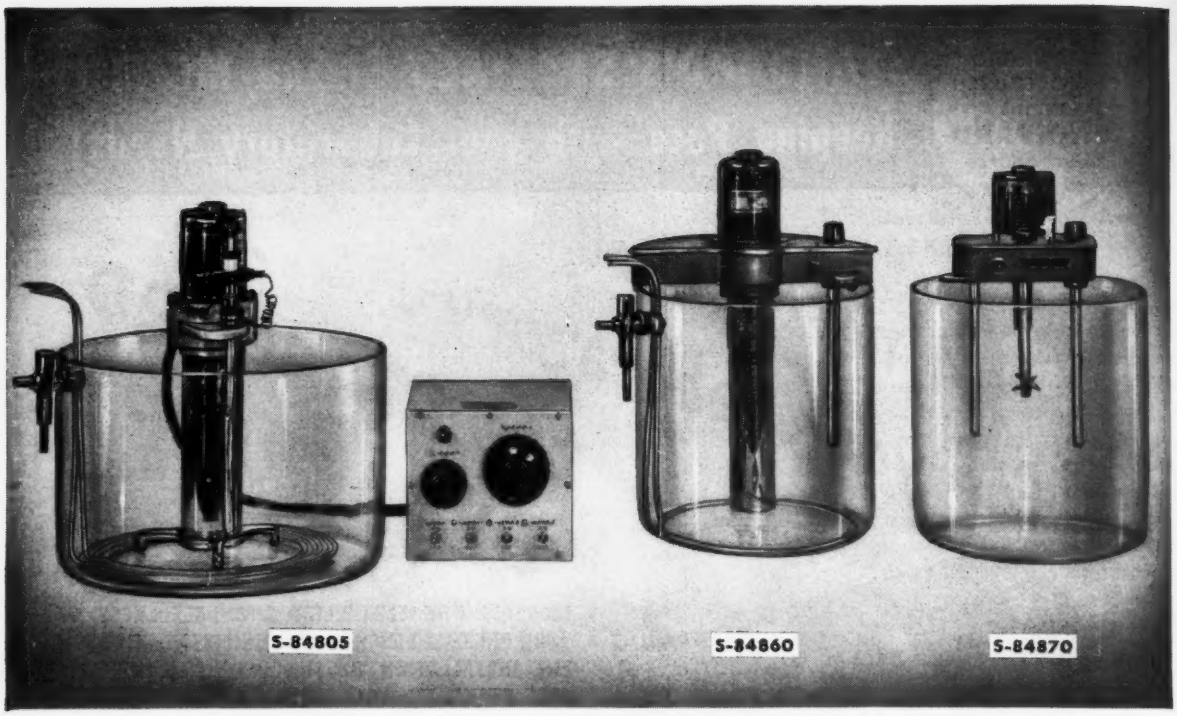

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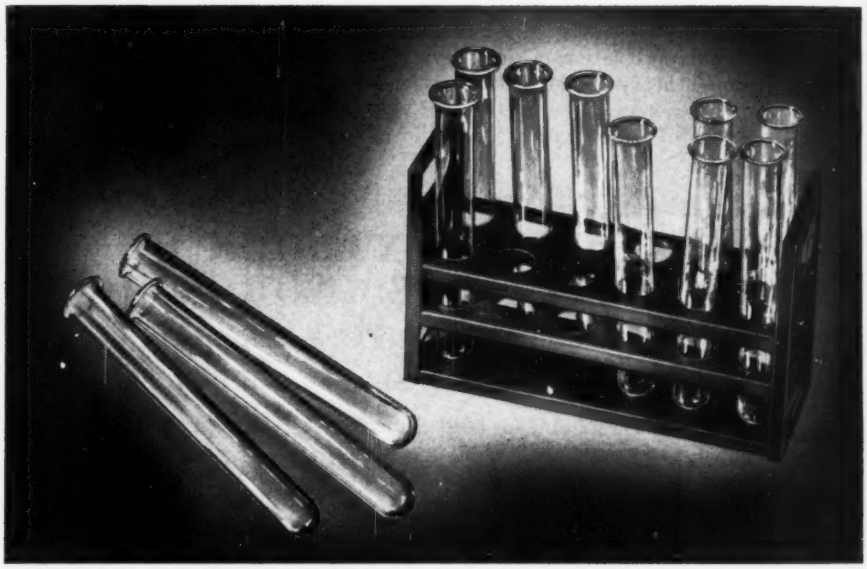

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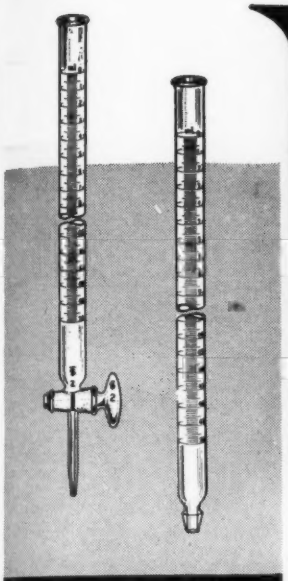

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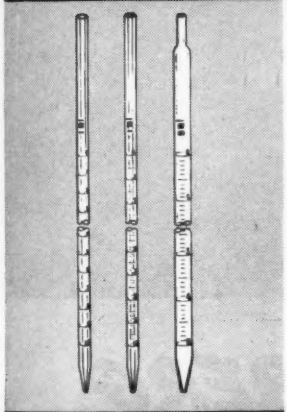

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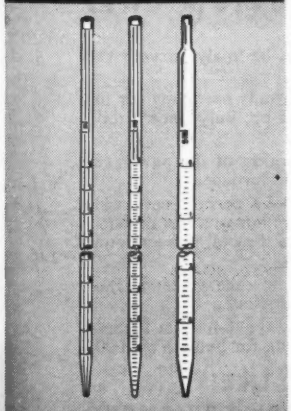

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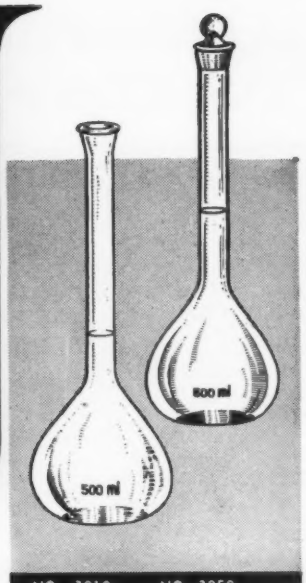

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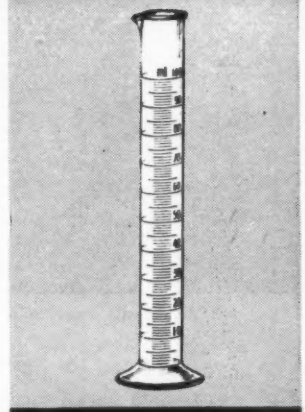

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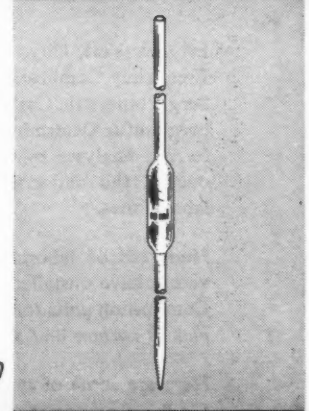

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5010	Burette, Pinchcock	10	24	24.40	23.25	22.15	21.10
		25	24	27.50	26.20	24.95	23.75
		50	24	27.50	26.20	24.95	23.75
4040	Pipette, Measuring	1	72	36.70	34.95	33.30	31.70
		2	72	36.70	34.95	33.30	31.70
		5	72	36.70	34.95	33.30	31.70
		10	72	41.70	39.70	37.80	36.00
4080	Pipette, Serological	1	72	40.00	38.10	36.30	34.55
		2	72	38.35	36.50	34.75	33.10
		5	72	38.35	36.50	34.75	33.10
		10	72	45.90	43.70	41.60	39.60
2010	Flask, Volumetric	10	36	18.75	17.85	17.00	16.20
		25	36	19.15	18.25	17.40	16.55
		50	36	20.00	19.05	18.15	17.30
		100	36	21.70	20.65	19.65	18.70
2050	Flask, Volumetric	10	36	30.45	29.00	27.60	26.30
		25	36	30.85	29.40	28.00	26.65
		50	36	32.10	30.55	29.10	27.70
		100	36	36.70	34.95	33.30	31.70
6050	Cylinder	10	72	40.00	38.10	36.30	34.60
		25	72	44.90	42.80	40.80	38.90
		50	72	51.60	49.10	46.80	44.60
		100	36	27.15	25.85	24.60	23.45
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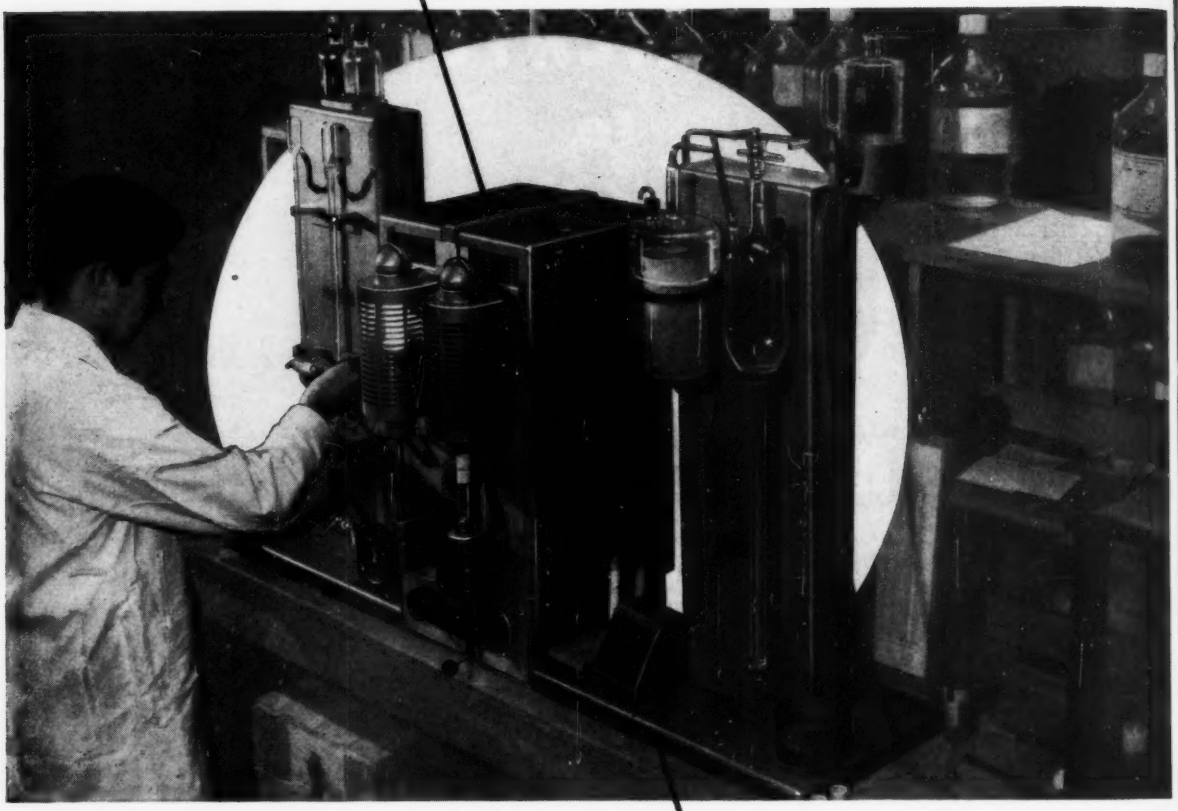

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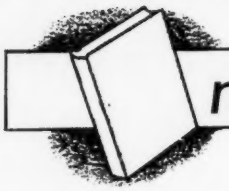

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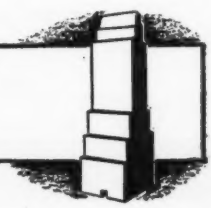

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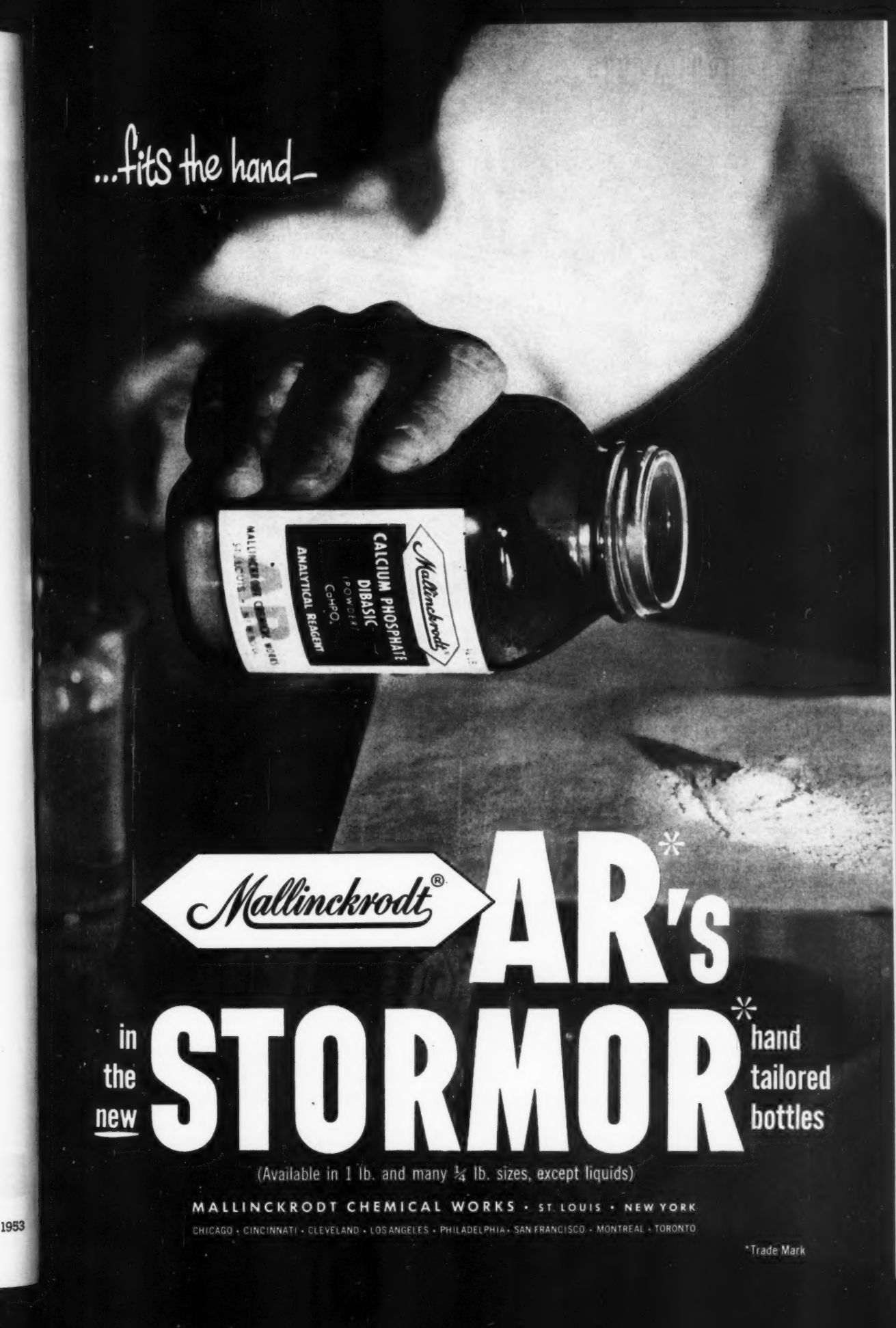
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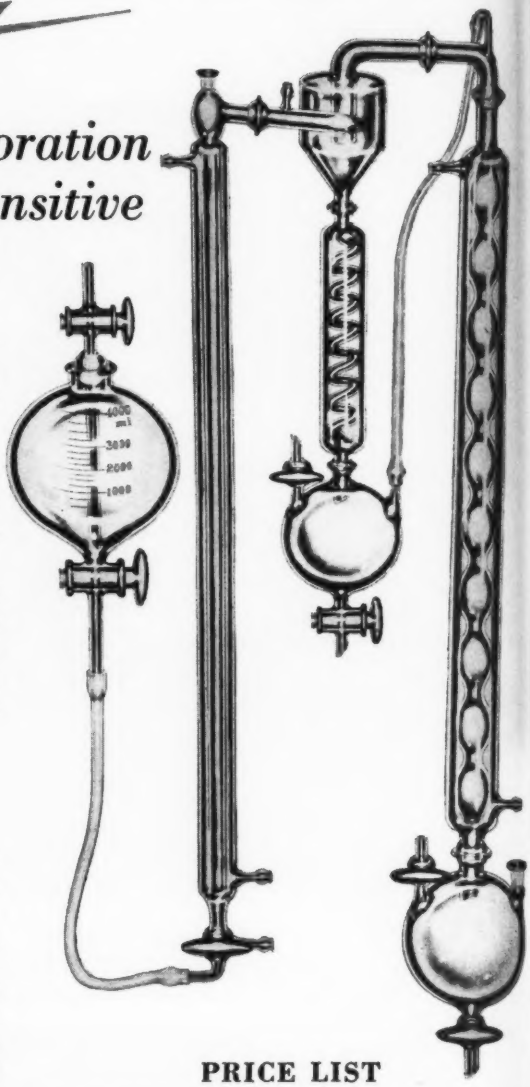

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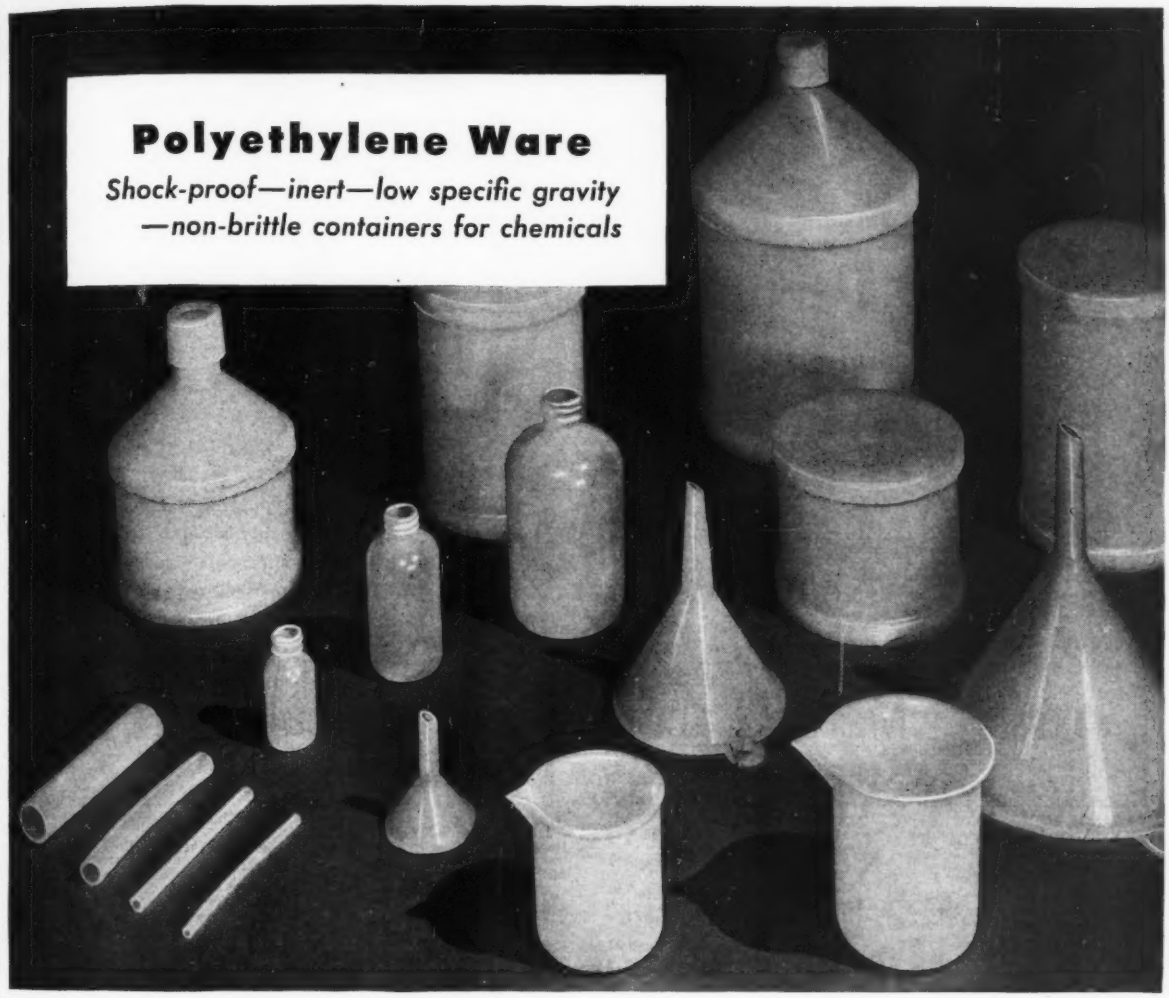

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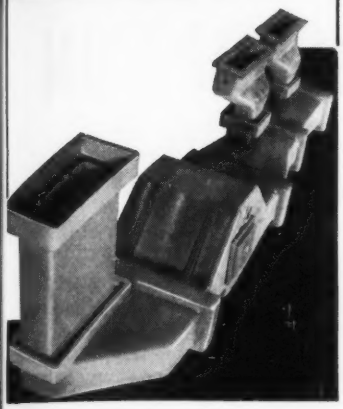

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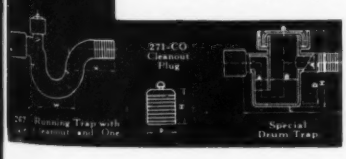

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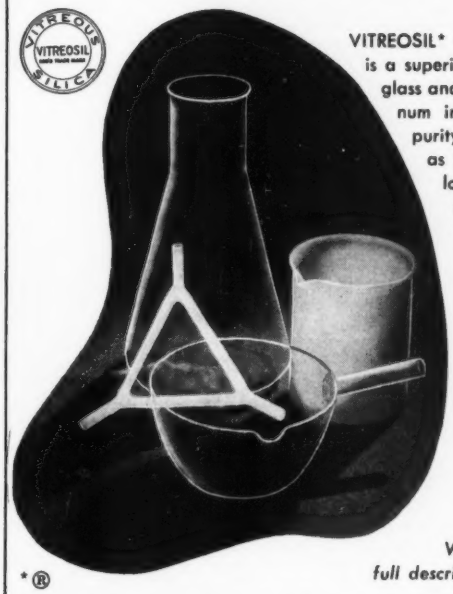

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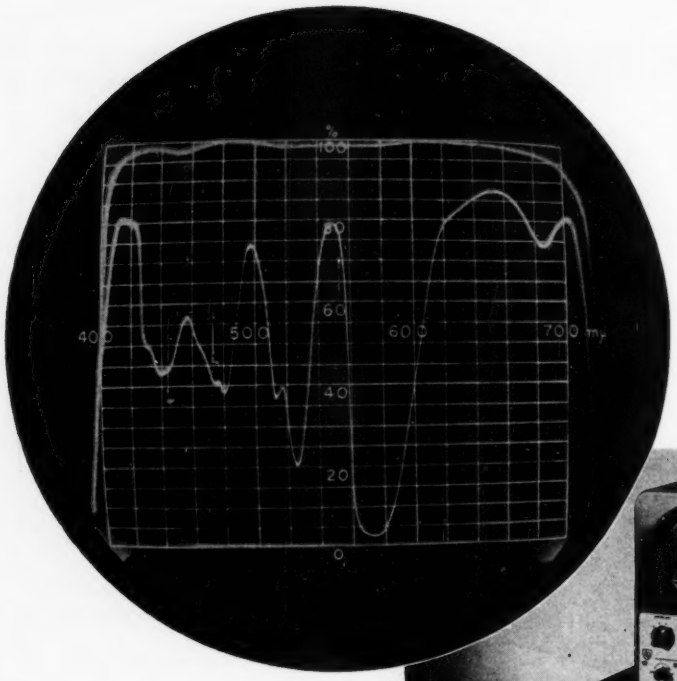

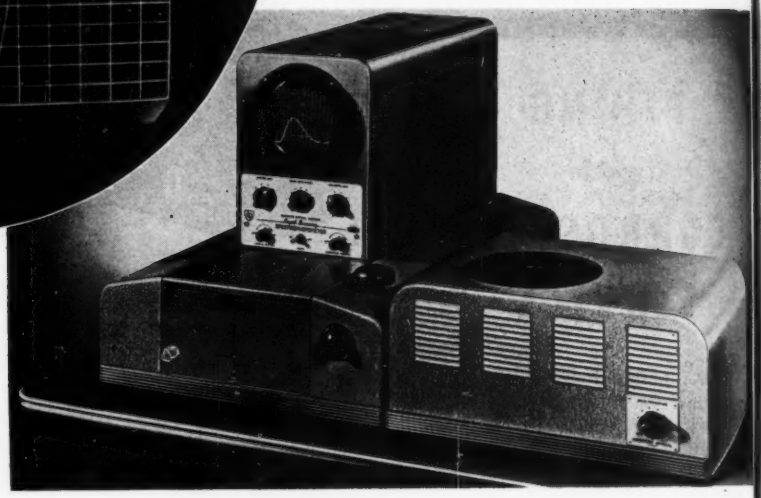

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(See page 510)

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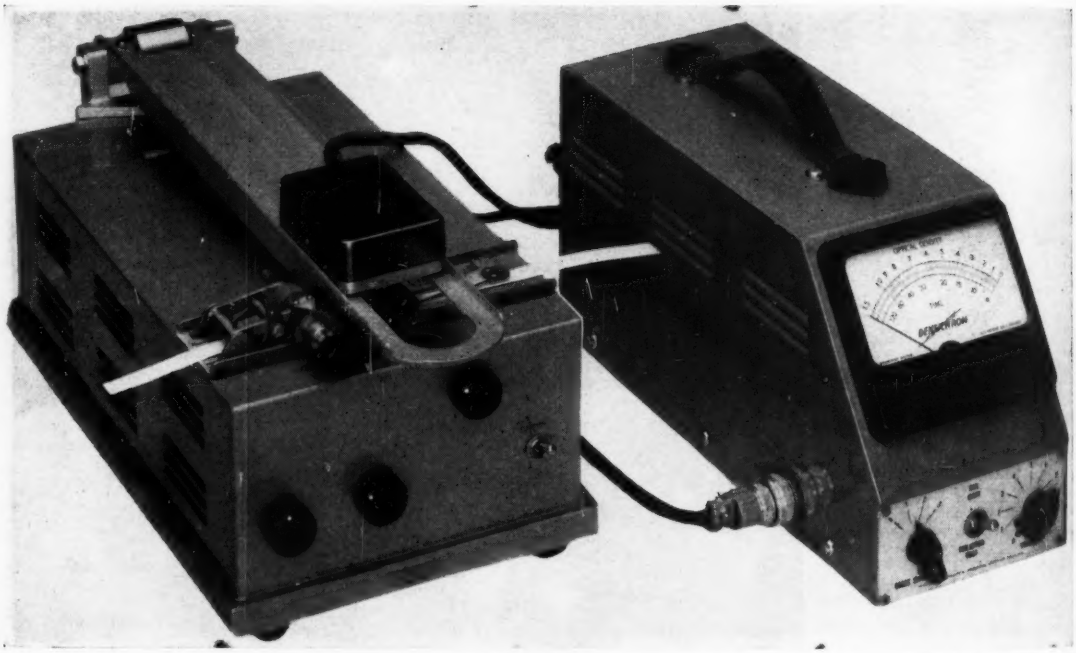

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Editor's Outlook

In an address at the last Graduate Commencement at Brown University Dr. Leonard Carmichael, past president of Tufts College and now Secretary of the Smithsonian Institution, made some remarks which are well worth keeping before us:

> Some of the fanciful lists of human rights and privileges that were so prettily printed in two great English-speaking capitals in the 1930's and which guaranteed many things from the cradle to the grave, really boil down to an invitation to the individual citizen not to work too hard. If a whole society is ever hypnotized by the odd idea that some sort of superstate can provide the necessities and even the luxuries of life without requiring individual responsibility and work, it will be hard for the scholar to realize that this attitude must never apply to him.

It is bad enough—perhaps even disastrous—to suggest to the "worker" that he not be so diligent as to risk overstraining himself, but if the scholars, scientists, and other brain-workers should be similarly seduced the result would be cataclysmic. Our country must live and survive by brain power; even the multiplication of our muscle power by the vast machinery of our civilization is not sufficient to keep us safely unless we use our full supply of brains on more than an 8-hour, 5-day schedule. In fact, the more the machinery the more the necessity for high-powered brains. And it is a far bigger problem than mere national survival.

The mind has at least one point of similarity to the muscular system; it thrives and grows by activity, the more vigorous the better. Some of our population may be starting to wither from the waist down from too much riding in automobiles, but that is relatively unimportant and only a matter of individual concern to them. But if many begin to wither from the neck up, from any mistaken notion that Uncle Sam will do all the necessary thinking for us all, we are headed for hard times.

There is some solace in the fact that mental accomplishment has always to a large extent carried its own reward. A thinker is really a creator and when he has accomplished something he takes pleasure from it to a degree that no manual worker can. When this drive slackens there is nothing really to replace it; fortunately, however, it has a way of renewing itself, at least from one generation to the next.

The human mind is no respecter of time-clocks and quitting-whistles, and when it begins to become conscious of these restrictions it is either getting old and rusty or isn't big enough to stand the strain. Do the biographies of the great men of science say anything about their quitting work punctually at four-thirty or jealously hoarding their vacation days? Young people about to enter such a career will necessarily think of these things and in finding their places may well be less concerned about working hours and social security than about the opportunity for freedom to use their minds. Let them search for the full meaning of the description of the scientific method: "Doing one's damndest with one's mind, no holds barred."

AN INTRODUCTION TO THE ELECTRON THEORY OF METALS

ROBERT A. LEFEVER
Massachusetts Institute of Technology,
Cambridge, Massachusetts

ALTHOUGH it is seldom necessary for a chemist to have a thorough understanding of the physics of metals, the increasing importance of semiconductors, new alloys, and less familiar elements makes it desirable to have some knowledge of the physical principles governing the properties of metals. The electron theory does not at present adequately explain some of the finer points in the behavior of metals but it does give a unifying approach to the broader aspects of the metallic state. The theory is based on a rigorous mathematical background. It can be outlined, however, with a relatively elementary treatment and the fundamentals are thereby easily grasped. The following discussion is designed to provide a general background for the understanding of metal physics as well as a basis for more advanced study.

CLASSICAL FREE-ELECTRON THEORY

In 1900 Drude[1] published the first extensive mathematical treatment of metallic properties. His calculations were based on the assumption that a metal consists of a periodic lattice of positive ions permeated by a gas composed of the valence electrons. As originally pictured, these electrons moved in a perfectly uniform electrostatic field, experiencing no difference in potential from point to point within the metal. The kinetic energy was assumed to be distributed according to Maxwell's law, with a mean value of $^3/_2\ kT$ ergs per electron (where k is the Boltzmann constant).

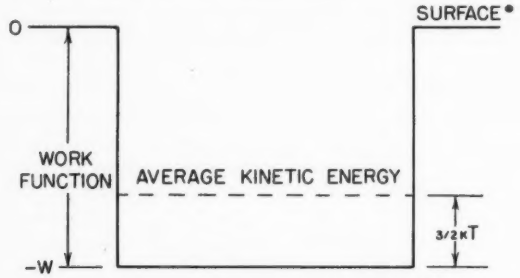

Figure 1. Potential Energy Box of a Metal at T°K.

Since these electrons are retained within the metal under normal circumstances, forces preventing escape were considered to exist at the surfaces and electrons within were accorded a lower potential energy than those outside. If the potential energy outside the metal is arbitrarily taken as zero, the energy inside becomes $-W$, where W is the work function or energy necessary to cause electron emission. Thus, the metal becomes a potential box of depth equal to the work function. At T°K., the average electron kinetic energy is $^3/_2kT$ above $-W$ as shown in Figure 1.

If the electron gas is considered to behave according to the ideal gas law, a simple calculation shows that the pressure within a univalent metal would amount to about 3,000 atmospheres.[2] This pressure must be counteracted by the electrostatic attraction between electrons and positive nuclei. Behavior according to the kinetic gas laws leads to the conclusion that an electron gas should have a specific heat of $3R/2$. Since the lattice of a monatomic crystal has a specific heat of $3R$, the specific heat of a metal should then be about $9R/2$. Experimentally the specific heat was known to approach a maximum value of $3R$ and this lack of agreement with the predicted value was one of the more serious shortcomings of the theory. To circumvent this difficulty the electron gas was endowed with the property of degeneracy wherein it contributed little or nothing to the specific heat at relatively low temperatures.

A second problem arose with regard to electrical properties. The ratio of thermal conductivity to electrical conductivity, known as the Wiedemann-Franz relation, was accurately predicted and constituted one of the major supports of the theory. The nature of the thermal dependence of electrical conductivity was poorly predicted, however. Using the principles outlined by Drude, Lorentz[3] derived an equation for electrical conductivity assuming Maxwell's law for velocity distribution. From his equation, the following expression for resistance can be obtained:[4]

$$R = \frac{3\pi}{8}\cdot\frac{\sqrt{3mkT}}{ne^2l} \qquad (1)$$

[1] DRUDE, P., *Ann. Physik* [4], **1**, 566–613; **3**, 369–402 (1900).

[2] One mol of a univalent metal, for example copper, contains a mol of electrons. Assuming these electrons to behave as a perfect gas, confined within the molar volume, V, of the metal, the pressure, P, exerted on the surfaces can be calculated with the equation, $PV = nRT$, where $n = 1$ and R is the gas constant.

[3] LORENTZ, H. A., "The Theory of Electrons," 2nd ed., G. E. Stechert and Co., New York, **1923**, pp. 67, 266–74.

[4] Substituting the mean velocity, $\mu = \sqrt{\frac{8kT}{\pi\, m}}$, and the proportionality between the mean kinetic energy and absolute temperature, $\alpha = 3k/2$, based on Maxwellian distribution in the equation, $\sigma = \sqrt{\frac{2}{3\pi}}\,\frac{e^2lN\mu}{\alpha\ T}$, given by Lorentz results, after inversion, in equation (1) where $n = N$.

where m is the electron mass, k is Boltzmann's constant, T is the absolute temperature, n is the number of free electrons per unit volume, e is the electronic charge, and l is the mean free path.

If the mean free path is taken as equal to the atomic spacing, the calculated electrical resistivity of copper has the correct order of magnitude *at room temperature*. As can be seen from equation (1), however, the change in resistance should be a function of the square root of the absolute temperature, which is not in agreement with the experimentally found linear relation.

Although the Drude-Lorentz electron-gas theory satisfactorily accounted in a general way for many metallic properties, its shortcomings were serious and only overcome by the application of quantum principles.

WAVE THEORY OF METALS

The application of quantum mechanical principles to metals was first proposed in 1928.[5] The wave picture is based on the assumptions that the valence electrons are free, as proposed by Drude, that these electrons occupy discrete energy levels in accord with quantum principles, and that the occupation of energy levels is governed by the Pauli exclusion principle.

The fact that some physical phenomena could not be completely explained by the separate application of either wave principles or classical mechanics first became apparent in the study of light radiation. Although the wave nature of light was well established by diffraction and interference experiments, the photoelectric effect indicated a particle nature as well. Once the wave-particle characteristic of light was recognized, the question of a similar state of affairs with regard to electrons soon arose. The experimental confirmation of wave as well as particle properties in the case of electrons was forthcoming in the work of Davisson and Germer.[6] A beam of electrons was shown to be capable of diffraction by a crystal lattice in the same manner as an X-ray beam and to have an associated wave length,

$$\lambda = h/mv \tag{2}$$

where h is Planck's constant, m is the electron mass, and v is its velocity.

A more convenient description of the wave properties can be obtained by using the concept of wave number, k, where,

$$k = 2\pi/\lambda \tag{3}$$

The resulting expression for the wave number is seen to be a measure of momentum or velocity:

$$k = \frac{2\pi}{h} \cdot mv \tag{4}$$

The kinetic energy of a free electron in terms of the wave number can easily be derived as follows:

$$E = {}^1/_2mv^2 \tag{5}$$
$$= {}^1/_2m(hk/2\pi m)^2 \tag{6}$$
$$= h^2k^2/8\pi^2m \tag{7}$$

This parabolic relation between kinetic energy and wave number is illustrated in Figure 2.

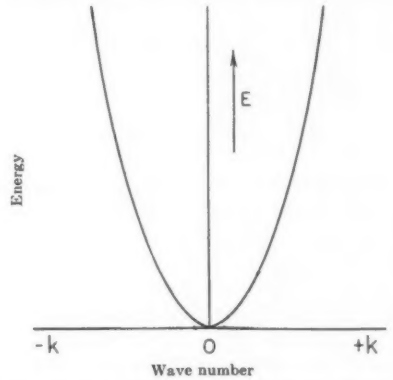

Figure 2. The Parabolic Relation Between Kinetic Energy and Wave Number

The problem of determining the available energy states and their distribution may be solved by considering the case of a hypothetical one-dimensional metal of length L. Into this length it is necessary to fit as many sinusoidal waves as theoretically possible. In view of quantum mechanical principles it is necessary that the wave function, Ψ, be sinusoidal and continuous. The three longest waves that fit the potential box representing the one-dimensional metal are shown in Figure 3. Curve (1), representing the longest wave,

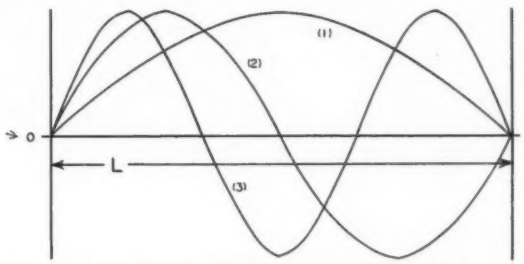

Figure 3. Three Longest Sine Waves for a "One-dimensional Metal" of Length L

has a length equal to $2L$ and subsequent waves have the wave lengths

$$\lambda = 2L/n \tag{8}$$

where n may be considered equivalent to a quantum number.

The energy levels available for electron occupation may be found from the kinetic energy as follows:

$$E = {}^1/_2mv^2$$
$$= {}^1/_2m(h/m\lambda)^2 \tag{9}$$
$$= n^2h^2/8mL^2 \tag{10}$$

Figure 3 illustrates the theoretical case in which the potential box has an infinite depth and, thus, the curves

[5] SOMMERFELD, A., W. V. HOUSTON AND C. ECKART, *Z. Physik*, **47**, 1–60 (1928).

[6] DAVISSON, C., AND L. H. GERMER, *Phys. Rev.*, **30** (No. 6), 705–40 (1927).

fall to zero at the ends. Since the depth is always finite, the curves actually extend somewhat beyond the ends before reaching zero but this refinement does not alter the qualitative picture. The solution of a three-dimensional system is more involved but the same reasoning applies and the resulting equation is

$$E = \frac{h^2}{8mL^2}(n_x^2 + n_y^2 + n_z^2) \tag{11}$$

or

$$E = \frac{h^2}{8mV^{2/3}}(n_x^2 + n_y^2 + n_z^2) \tag{12}$$

With this background we are now in a position to compare the wave theory with the original Drude-Lorentz picture. According to the Pauli exclusion principle, only two electrons may occupy any one energy state. Thus, at absolute zero, $N/2$ energy states are occupied where N is the number of free electrons. The energy states fill in order of increasing energy until the state of maximum energy, $E_{max.}$, is reached. Thus, even at absolute zero some electrons have high energy while, in comparison, all electrons of the free-electron-gas theory have zero energy. $E_{max.}$ can be expressed[7] as follows:

$$E_{max.} = \frac{h^2}{8m}\left(\frac{3N}{\pi V}\right)^{2/3} \tag{13}$$

where N/V is the number of electrons per unit volume.

The state of affairs at absolute zero may be elucidated by plotting the probability of an energy state being occupied by electrons against energy. Such a distribution curve is shown in Figure 4. As the temperature

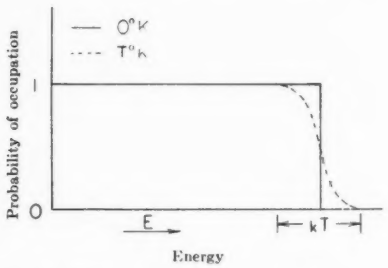

Figure 4. Electron Distribution Curve

increases, only the higher energy electrons can further increase in energy, since available energy levels lie only above them. Only electrons with energies above $E_{max.} - kT$ can increase in energy, and at room temperature this is only about one per cent of the total number. This accounts for the small contribution of the electrons to the specific heat of a metal.

The following equation for the resistance of a metal results from the quantum mechanical theory:[8]

$$R = \frac{mv}{ne^2l} \tag{14}$$

where v is the mean velocity of the conducting electrons, n is the number of conducting electrons per unit volume, m is the electron mass, e is its charge, and l is the mean free path. In order to have a calculated resistance of the correct value, it is necessary to assume a mean free path of about 100 atomic spacings. On first sight this appears to present a serious problem. Resistance according to the wave theory, however, is not the result of collision or deflection of single electrons but rather the scattering of a wave front by lattice imperfections. In a perfect lattice at absolute zero the mean free path is very long. As the temperature increases the lattice points undergo thermal vibration, causing lattice imperfections that scatter the wave front. The mean free path of electrons can be shown to vary inversely with the square of the amplitude of atomic vibration and thus inversely as the first power of the absolute temperature. Thus, the experimentally found linear relation between resistance and temperature is predicted by theory. Extensive calculations have shown the theory to be correct not only qualitatively but quantitatively as well.

THE ZONE THEORY

Although the quantum mechanical theory went a long way toward explaining the behavior of metals, it did not include solids in general. In order to explain the high resistance of insulators it was necessary to resort to an entirely different model. Lack of conductivity was assumed to be the result of strong binding of electrons by homopolar bonds to specific atoms. With the development of wave mechanics, however, and the accompanying realization that there exists a definite probability of movement of even a tightly bound electron, this picture of insulators began to appear inadequate. In fact, calculations clearly indicated that the strong binding of electrons in the better insulators could result in a resistance of only about 100 times that of a metal.[9]

The fact that a definite probability exists for an electron of insufficient energy to pass over a potential barrier indicated that all solids might be combined under a single theory and that a different interpretation of insulators must be found. The development of the wave-mechanical theory was based on a perfectly uniform electrostatic field within the metal. It is now assumed that the field varies periodically with the distribution of positive ions. In other words, as an electron passes in the immediate vicinity of an ion it experiences a change in attractive force. The combination of the wave theory with this periodic electrostatic field leads to some interesting conclusions.

When electrons with a wave length, λ, are diffracted by a crystal lattice they obey the Bragg relation,

$$n\lambda = 2d \sin \theta \tag{15}$$

[7] HUME-ROTHERY, W., "Atomic Theory for Students of Metallurgy," 2nd ed., The Institute of Metals, London, 1952, pp. 165–70.

[8] COTTRELL, A. H., "Theoretical Structural Metallurgy," Edward Arnold and Co., London, 1948, p. 78.

[9] HUME-ROTHERY, W., *op. cit.*, p. 213.

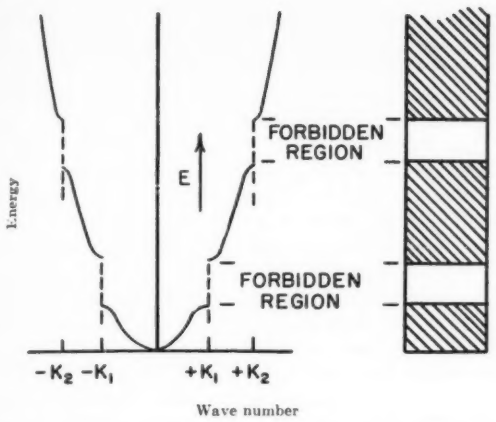

Figure 5. Energy Discontinuities Resulting from Electron Diffraction

where n, an integral number, is known as the order, d is the distance between diffracting planes, and θ is the glancing angle of the beam. Electrons *within* the metal may be assumed to behave in the same manner, and those with wave lengths satisfying the Bragg relation will be diffracted when experiencing a lattice of appropriate periodicity. In considering any particular direction of motion relative to a set of diffracting planes, the wave lengths satisfying the Bragg equation constitute forbidden energy values. That is, electrons with these energies would be forced to immediately change in direction or energy. The wave numbers at which this occurs may be found as follows:

$$\lambda = \frac{2d}{n} \sin \theta$$
$$k = 2\pi/\lambda$$
$$= \frac{n\pi}{d \sin \theta} \tag{16}$$

As shown in Figure 5, the first discontinuity occurs at $\pm k_1$ when $k = \pi/d \sin \theta$, the second discontinuity occurs at $\pm k_2$ when $k = 2\pi/d \sin \theta$, etc. The $E=k$ curve deviates from the parabolic shape in the vicinity of the forbidden energy values in such a way as to cause forbidden regions. Although the same E-k curve serves for all crystallographic directions, the discontinuities appear at different positions along the curve, since different periodicities are experienced in different directions. Figure 6*a* shows the appearance of the curve for two different directions. This situation of overlapping energy levels is encountered in low-valence metals where ionic charge is low and diffuse. Figure 6*b* represents a high-valence solid giving broad forbidden regions. When energy levels overlap, an electron at the top of one level, or zone, can increase in energy by changing direction whereby it is governed by a different zone. On the other hand, an electron having the maximum energy permitted by the direction represented by the lower curve *b* in Figure 6*b* cannot increase in energy.

The matter may be further elucidated by utilizing the concept of k-space. This is accomplished most easily by considering a two-dimensional metal with a simple periodic lattice, as illustrated in Figure 7. The first discontinuity, or boundary of the first Brillouin zone,

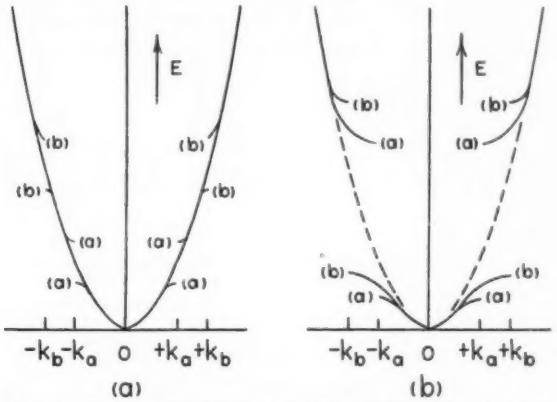

Figure 6. Energy Discontinuities in Different Directions. (a) Overlapping Zones, (b) Non-overlapping Zones

results when conditions are such that first-order reflection occurs. From equation (16), this can be seen to result when

$$k = \frac{\pm \pi}{a \sin \theta} \tag{17}$$

If the vector k is resolved into its components, k_x and k_y, the component k_x, normal to the planes parallel to the y direction, is equal to $k \sin \theta$, and thus,

$$k_x = \frac{\pm \pi}{a} \tag{18}$$

This means that a discontinuity occurs at $\pm\pi/a$ for all electrons with an x component of the wave number

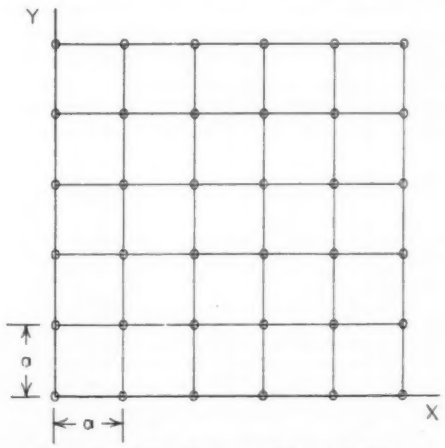

Figure 7. A Two-dimensional Square Lattice

equal to $\pm\pi/a$. Similar reasoning shows that the discontinuity in the y direction occurs at

$$k_y = \frac{\pm \pi}{a} \tag{19}$$

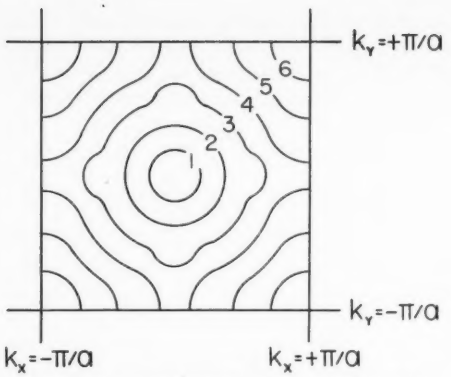

Figure 8. Equal Energy Contours in the First Brillouin Zone of the Square Lattice

The k-space delineated by these limits, known as the first Brillouin zone, is illustrated in Figure 8. Within this zone are plotted six equal-energy contours. The region outside of the first zone boundary represents the beginning of the second zone. The expansion of contour 4 in the neighborhood of the zone boundary corresponds to the deviation of an E-k curve from the parabolic shape in the vicinity of a forbidden region.

Whether or not zones overlap depends upon the relative energies of the electron states in the two zones. If the lowest energy state of zone two is lower in energy than the highest energy state of zone one, the second zone will begin to fill before the first zone is completely full. On the other hand, if the lowest energy state of zone two is *higher* in energy than the highest energy state of zone one, zone one will fill completely before the second zone begins to fill. In the latter case, the magnitude of the energy difference between the low energy state of zone two and the high energy state of zone one is equivalent to the size of the forbidden region.

Extension of the zone theory to three-dimensional solids results in three-dimensional k-space diagrams. The shapes of these diagrams depend upon the type of crystal lattice and are relatively simple for high lattice symmetry. Figures 9*a* and 9*b* illustrate the first

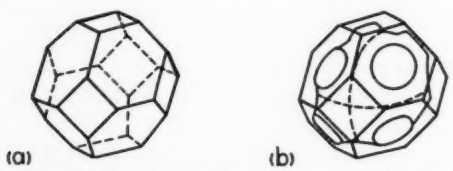

Figure 9. First Brillouin Zone for a Face-centered Cubic Lattice. (a) Empty Zone, (b) Zone Containing Electrons

Brillouin zone for a face-centered cubic lattice. The effect of energy-state distortion can be seen in Figure 9*b* where enough electrons are present to cause filling of some of the lower energy states at the first zone boundary.

The importance of whether zones overlap or not may be illustrated by considering electrical conductivity. The number of energy states available for electron occupation in one zone is equal to the number of atoms in the lattice. Thus, a monovalent metal will have enough electrons to half fill the zone, since two electrons can occupy each level. When an electrical potential is applied, the highest energy electrons with k vector components in the direction of the field will increase in energy. Resorting to the two-dimensional system again, Figure 10*a* represents the situation described. The solid circle illustrates the original electron distribution, while the broken circle gives the distribution under an applied field.

The electrons actually contributing to the current are those within the shaded area (*i.e.*, those without opposing vectors). Continuous acceleration of the curve is prevented by scattering of the wave front as it experiences lattice imperfections and impurities. Figure 10*b* illustrates the case of a hypothetical divalent solid in which zones do not overlap. Since there are two valence electrons per atom, the zone is completely

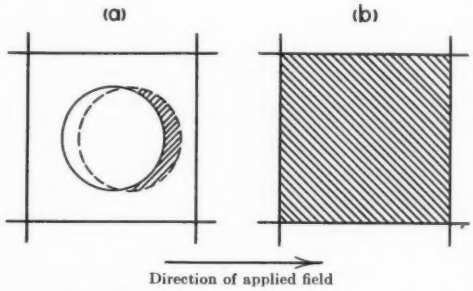

Figure 10. Application of an Electrical Field, (a) to a Partly Filled Zone, (b) to a Filled Zone

filled. Application of an electrical field cannot result in an energy increase for any electron, since they are all surrounded by a forbidden region. Thus, the material represented is an insulator. If the zones overlap, as in the case of the alkaline earths, zone one is not full and zone two contains some electrons. In this case, higher-energy electrons can increase in energy and the metal is a conductor. Most of the common insulators are the result of a filled higher zone surrounded by a forbidden region. Insulators and conductors have in this manner been combined under a single theory in which the distinguishing feature is the nature of the forbidden energy levels.

Although the principles outlined above should serve as an introduction to the subject, the reader who wishes to investigate the electron theory of metals more thoroughly would do well to study a more detailed account of the fundamentals[10–12] before considering a more rigorous treatment.[13, 14]

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SOME RECENT DEVELOPMENTS IN STEEL PRODUCTION AND PRODUCTS[1]

WILLIAM A. DENNIS
United States Steel Company, Boston, Massachusetts

IT IS my intention to take you on a rapid trip through steel production from the iron ore fields to some of the finished steel products. As we proceed along the way I hope to be able to highlight the various units by pointing out some of the newer developments taking place. Naturally it will be impossible to point out all of the progress made in recent years but I will attempt to give examples of improvements both in processes and products which, despite mounting costs, continue to provide an inexpensive material which is made into many of the necessities and luxuries in our daily life.

IRON ORE

Some of the most important development work now being conducted is in iron ore. This is not only important to the iron and steel industry but to the nation as a whole. Two world wars have been fought and won largely by the rich, open-pit mines of the fabulous Mesabi and other great iron ranges, with the famous Hull-Rust mine at Hibbing, Minnesota, carrying a large portion of the load. World War II chopped some 340 million tons from these reserves and at the present rate of consumption it has been estimated that these fields will be, to all practical purposes, exhausted by 1970. It is not, therefore, by accident that an arduous search has been undertaken to find new sources of iron ore to replace the great supplies upon which the industrial foundations of our country have been built. It is, then, with a grave sense of responsibility that the steel industry has in recent years expended large sums of money and thousands of man-hours of technical personnel in an effort to find a solution to this problem. Fruitful results have been obtained in the development of the rich fields of Laborador and Quebec, and while these fields are of the utmost importance they will not adequately replace the supplies of the past from the Lake Superior region. However, by 1960, when the tremendous transportation problems involved have been resolved, it is expected that the Canadian region will yield some 10,000,000 tons annually—a long step toward the alleviation of our national problem. The most spectacular development, however, has been the discovery in Venezuela in 1947 of "Cerro Bolivar," a veritable mountain of high-grade iron ore equal to or even surpassing in quantity and quality the Hull-Rust Mine of Minnesota. This search for new sources of ore was started in 1945, and by 1946 field workers were in Brazil, Venezuela, Honduras, Guatemala, Puerto Rico, Cuba, Mexico, Sweden, and other locations throughout the world.

In addition to these new important ores from Canada and Venezuela, development work in the processing of low-grade iron ores is rapidly reaching an impressive production basis. In addition to the rich iron ore deposits in both the Lake Superior and Michigan areas there are also large deposits of taconite, a low-grade ore, which is a mixture of hematite and magnetite in a matrix of rock. The crystals of both minerals exist in a variety of combinations. If, as is the case in the Superior ores, the proportions are two parts magnetite to one part hematite, the processing is generally as follows: The taconite is ground to a fineness dictated by the crystal size of the magnetite, and the magnetite is then separated on a magnetic separator and the rock and hematite are discarded as tailings. The fine magnetite must then be agglomerated in some manner such as sintering to make it suitable for charging in the blast furnace. Unfortunately the taconites of Michigan are in reverse, *i.e.*, two parts hematite to one part magnetite, and the ore must be treated by heating to make it magnetic or the iron minerals must be separated by other than magnetic means.

In any event, the ore picture looks brighter than at any time since the beginning of World War II, and the Canadian and Venezuela ores will serve to maintain the economic basis to which we are accustomed for a long time to come. The development of the taconites at huge expenditures, coupled with the conservation of Superior ores, should afford the supplies needed in times of emergency.

BLAST FURNACE

Over the years, most of the development work on the blast furnace has been concentrated on mechanical equipment. However, research workers are today concentrating on the metallurgy and chemistry of these giants of industry. It has always been a dream of the steel mills to find an economical method of making steel directly from iron ore, and many such proposals have been made, but as yet none has been found economically or metallurgically feasible. It may well be that, with the concentration of research effort now being expended, this dream of steel producers may some day be a reality.

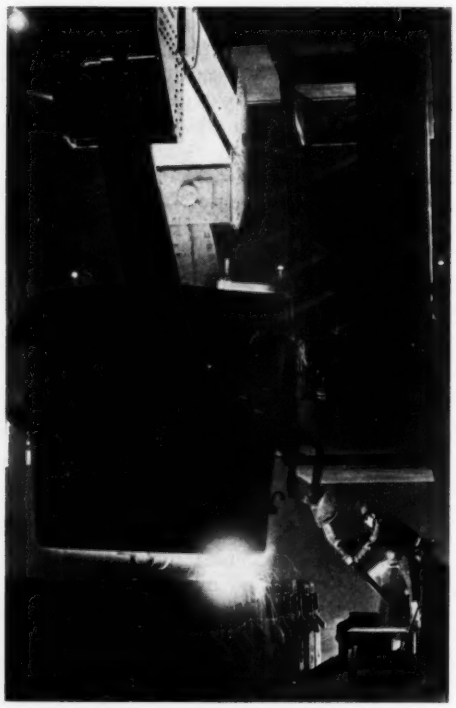
One of the most outstanding recent developments in the blast furnace is the work on the high-pressure top. The great demand of the war and postwar periods for iron and steel products has placed emphasis on more and

[1] Based upon an address presented at the 14th Summer Conference of the New England Association of Chemistry Teachers, University of Vermont, Burlington, Vermont, August 20, 1952.

more production from existing facilities as well as the construction of new units. It has long been known that greater blast furnace production can be effected with an increase in the blowing pressure of the air, but the limit of this pressure has been governed by the velocity of the exhaust gases which, when too high, cause furnace operating irregularities. In an effort to augment production it was proposed that if the top static pressure of the blast furnace could be increased, the blowing pressures could also be stepped up and the velocity of the gases through the furnace decreased. Operations of the blast furnaces, with pressures raised from two to ten pounds per square inch, have resulted in reported increases in production of 11 to 20 per cent, with a decrease in coke rates of 13 per cent, and a cut in the production of flue dust of 30 per cent. In addition to these savings, smoother working furnaces with resultant longer campaign life may be expected.

OPEN HEARTH AND BESSEMER

As in the case of the blast furnace, the chief emphasis in the open-hearth shops has been on more and more production. To accomplish this objective furnaces have been enlarged by as much as one-third or more. While the bath area in some furnaces has been extended, greater production did not come so much from larger furnaces as from larger ladles and other handling facilities to receive the molten product of the enlarged furnace charges. General over-all skill and efficiency have also added their share to the increase in production rate year by year. At the beginning of World War II in 1939 the capacity of the steel industry was some 63,000,000 ingot tons. By 1944, the peak war year, the capacity had been increased to 90,000,000 tons and in 1951 to 105,000,000 ingot tons. The rated capacity now is over 110,000,000 ingot tons and capacity forecast for next year is almost 120,000,000 ingot tons or nearly double the capacity of 1939.



A 100-ton Ladle of High Quality Steel Being Teemed into Hot-top Ingot Molds in the Electric Furnace Department at the South Chicago Works of U. S. Steel

One of the more recent means of accelerating open-hearth production is the use of oxygen. Oxygen has been tried in two ways: (1) to speed decarburization by introducing oxygen directly to the bath, and (2) to increase fuel efficiency by introducing oxygen at the burner. In the case of decarburization the method is simple. Oxygen is usually supplied at 100 pounds per square inch at the feed end of a hose. Standard lengths of clean pipe are used as lances, which are immersed about 8 inches below the bath surface. In a few cases a water-cooled jet is used, and where this jet is employed the oxygen is introduced above the bath and blown through the slag. The reduction of carbon in open-hearth steelmaking proceeds slowly as the carbon content of the bath is reduced. In the lower ranges (0.03 to 0.20 per cent carbon), reduction is accelerated by the use of oxygen, with the net result that the time required to produce the product in the open-hearth furnaces is materially reduced.

Oxygen may be used, also, to supplement the air required for combustion of the fuel. For the same weight of fuel burned, the use of oxygen diminishes the quantity of the products of combustion, thereby increasing the flame temperature and decreasing the amount of heat carried off by the outgoing gases. To use the heat efficiently and to avoid premature refractory failure, the increased heat must be absorbed, and this is best done by the cold scrap charge, so that oxygen is used in this manner during the melt-down prior to the hot iron charge. Good coordination in the rate of scrap charging is important, and the physical layout of some plants would prevent the efficient coordination required. In cases where plants can use oxygen in this manner, increases of 1.5 tons per hour have been reported.

Use of oxygen in the Bessemer process has also been studied. Oxygen affords the same opportunity for greater efficiency in this process. In addition, nitrogen, which has been the cause of limiting the use of Bessemer steel in some cases, can be maintained at a low level by the use of oxygen. Oxygen has been used mostly where a deficiency of hot metal has been encountered, and a larger proportion of scrap charge is desired. There is, however, a definite relationship between hot metal, scrap, and oxygen usage, and beyond these limits increase in production can only be made at the expense of both quality and economy. In the basic converters, which are common in Europe, the use of oxygen enabled the Germans to produce some high-quality steels during the war.

TURBO-HEARTH

The basic open-hearth and acid Bessemer processes possess certain inherent advantages, universally recognized and applied. The basic open hearth now accounts for 90 per cent of the steel production in the country; the acid Bessemer for about 5 per cent. In the latter part of the nineteenth century the Bessemer accounted for 75 per cent of the ingot tonnage. Some of the important factors contributing to the increase in open-hearth tonnage are: (1) the capacity of the open hearth to use large tonnages of iron and steel scrap, (2) the ability of the open hearth to produce large tonnages of quality steels at competitive costs, (3) inherent properties of acid Bessemer steel, now attributed to the high content of phosphorus and nitrogen, which made its product less suitable than open-hearth steel for certain applications. On the other hand, the Bessemer process offers the very attractive advantage of not requiring any external heat. The Thomas process, widely used in Europe, has eliminated the high-phosphorus content but not the nitrogen. This process is limited to high-phosphorus iron which is not available in quantity in this country.

The attractions offered by the advantages of both processes has led to a search for some process possessing the attributes of both. Independent work by the Jones & Laughlin Steel Corporation and the United States Steel Company (carried out by the Battelle Institute of Columbus, Ohio) has been coordinated in an effort to reach this goal and very promising results have been obtained. Several operating problems normally associated with a new process are now the subject of further study. A good product has been rolled from some of the experimental heats and it is believed that the process can yield a quality equivalent to the basic open hearth, from basic iron.

ROLLING OF STEEL

Thus far we have discussed the various steelmaking processes. While steady progress in the improvement of old and development of new processes has gone forward in these units, parallel progress has been made in the forming of steel. Perhaps the most significant work has been in the thinner flat-rolled products from which most of our consumer products are made, such as automobile bodies, refrigerators, stoves, and the myriad of other appliances which we encounter in daily use. The great transition in the use of continuous rolling mills, both hot and cold, can hardly be classed as recent. Most of the work done began in the 1920's and was greatly accentuated by the intensely competitive depression years, the demand for high production in the war years, and the era of mounting production and elevated costs in the postwar period. The continuous process in hot rolling sheets consists of many roll stands in tandem wherein a slab some 4 to 6 inches thick and weighing about 5 tons is rolled to sheet gages as light as 0.050 in. and coiled or cut to length automatically as the long ribbon leaves the exit or finishing end. Formerly,

Bessemer Converters, National Tube Division, U. S. Steel, Lorain, Ohio

this same product was available in cut lengths only and was fed back and forth by hand in what were commonly called the hand mills. Very few of these old mills are left and they are fast passing from competitive position except for some specialty products.

A more recent development in this product has been the revolution in the method of tin plating of sheet steel which is the basic product used in all types of can manufacture. After rolling in the hot strip mill and coiling the sheet, coils are continuously pickled and cold reduced to the light gages required for cans. The production of long coils by the continuous rolling process afforded the industry an opportunity to develop the electrolytic tin plating of steel. Pilot lines were introduced about 1937. In the immediate prewar period this electrolytic tinning had progressed to a production figure of about 50,000 tons per year. Since the electrolytic coating is light, *i. e.*, $^1/_2$-pound coatings per base box (the base box is the unit of measure of tin plate and is equivalent to 112 sheets, 14 by 20, or 31,360 square inches), this prewar electrolytic tin plate was confined mostly to "dry" packs, particularly coffee cans. It was fortunate that the can technologists had conducted early experimental work on wider application of this product, since in 1942, after the loss of Far Eastern tin producing areas to the Japanese, the conservation of tin plate became critically urgent, if we were to continue to feed our armed forces as well as the people at home. This challenge was admirably met through research and development work by steel producers and can makers. Progress has continued in this field since the war and today electrolytic tin plate represents over 60 per cent of American production. To make this process more and more automatic in order to furnish cheaper cans and to conserve critical materials, such innovations as continuous annealing, differential coating, electronic

inspection and sorting, and other improvements have been and continue to be added almost daily to this already highly mechanized process.

HOT-EXTRUSION

It has long been hoped that steel could be hot-extruded into various intricate shapes. Development work along these lines has engaged many technicians both in America and abroad over the past decade. The hot-extrusion of metals has been established for some time in the nonferrous products, but the high temperatures necessary for working steel have made operating and die costs prohibitive. Considerable study has been made using graphite and carbonaceous materials for a lubricant to protect the dies. Research and development work at Persan, France, dating back to 1940 has resulted in the Ugine-Sejournet process using glass as a lubricant. The glass melting on contact with the hot steel prevents seizing of the billet and tools, and insulates the tools from the heat of the billet. It is claimed that both solid shapes and seamless tubing can be extruded by this process. Already a 2,500-ton press has been installed and is in operation at the Babcock & Wilcox Tube Company, Beaver Falls, Pennsylvania; and the National Tube Division, U. S. Steel Corporation, Gary, Indiana, at present has a 2,500-ton press. Billets can be heated by either gas furnaces or electric salt baths. The billets, after heating, are transferred to an inclined surface which is covered with a fiber glass mat; the billet rolls down the incline plane fusing to the glass mat and picking it up. The ram or mandrel may be covered with a fiber glass sock. In any event many alloy steels previously unpenetrable have been pierced and extruded on the press. Small runs, previously undesirable on large mills are produced profitably, since die changes are relatively inexpensive. Many new uses for this new tool of the ferrous industry will develop.

PRODUCTS

I should like to cite a few examples of the steel products which have also been developed to meet the needs of industry.

USS 17-TV. In 1948 the manufacturers of television tubes were faced with a problem. The demand was for larger picture tubes and the solid glass tubes were becoming more cumbersome. The tube makers turned to the steel producers for a solution. When heated and cooled, glass and most metals expand and contract at different rates causing the glass to crack when the two are sealed together. A steel with expansion and contraction similar to glass had to be used. The steel had to be easy to form and capable of withstanding pressures caused by the vacuum inside the tube. A stainless steel containing 28 per cent Cr originally proved to be the only steel with proper expansion or contraction. Additional development work resulted in a 17 percent Cr steel which was considerably cheaper and possessed everything but the proper expansion characteristics. A series of small laboratory heats were made which finally resulted in a product which was cheaper, formed easily, and did not crack the glass on sealing.

MX-Steel. Another significant product development has been in the field of free-machining steels. For many years B-1113, a highly resulfurized steel, had been the outstanding product for use in automatic screw machines. Too frequently heats of similar analysis gave good and bad results, and an unexplainable "something" remained to be resolved. A research program of several years duration was inaugurated which included the development of machines for testing, as well as coordinated production runs. Several steel companies worked on this development independently. It was found that a lower carbon and silicon content with closely controlled Bessemer blowing practice gave a globular-type sulfide inclusion as contrasted to the usual stringer type. Machinability in large production quantities has proved that this new steel, while costing slightly more because of the closer control required in manufacture, has resulted in increased machining production results from 30 per cent upward and at the same time tool-life has been increased an equivalent amount. Similar work is continuing on many other types of steel.

Electrolytic Tin Plate at U. S. Steel's Irvin Works

Boron. Like the tin, previously mentioned, the outbreak of World War II found us strategically short on many alloys needed for the production of planes and armaments. Notable among these scarce elements were chromium, tungsten, and nickel. Metallurgists had noted prior to this time that the alloying additions in steel had a multiplying effect on hardenability—that property in steel which governs the depth to which a section of steel can be hardened and which gives to heat-treated steel its strength and toughness. Seizing quickly on this thought the National Emergency steels (better known as the NE steels) were brought into being and small amounts of three elements, such as Ni-Cr-Mo, replaced large amounts of single elements such as nickel or chromium. By this method a relatively thin supply of strategic elements served us well and adequately despite the gigantic requirements of so huge a war effort. With the outbreak of hostilities in Korea and the tremendous demand of our present defense activities new critical shortages are plaguing us, notably in such common elements as nickel and molybdenum. Even the NE steels of World War II could not conserve an adequate supply of these elements for present strategic applications. Leaning back on investigational work conducted during and since the war, another element, boron, has been added to the list of substitutes which by judicious use will help immeasurably in this latest conservation effort. Boron as an alloying element is in a class by itself; minute amounts when added to steel impart remarkable hardening properties, or hardenability. For example a chart shows the following comparison:

Base composition	*Equivalent percentage of alloy needed in place of boron*			
	Mn	*Ni*	*Cr*	*Mo*
1020	0.85	2.4	0.45	0.35
1040	0.65	1.9	0.35	0.25
1060	0.45	1.2	0.20	0.15
1080	0.15	0.4	0.07	0.05

This is a remarkable table when it is considered that we are talking of boron in the order of 0.001 to 0.003 per cent. It should be pointed out that boron is only a substitute where hardenability is required and does not influence such special properties as impact strength at high or low temperatures, or corrosion resistance, but its use where hardenability is the prime requirement has progressed a long way toward conserving the strategically scarce elements required for our present defense effort.

CONCLUSION

I have been able to highlight only a few of the many thousands of new developments in the manufacture of steel. I regret that I have been unable even to mention, much less describe, other important developments, such as the spectacular uses of the spectroscope as a production tool for rapid chemical analyses in many melt shops and for controlling the Bessemer operation; the direct-reading spectroscope, producing chemical determinations in a matter of seconds; the supersonic reflectoscope with which we can peer into solid metals; and the many other tools, processes, and products which have been adopted as the result of careful research and development efforts.

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THE DEFINITION OF "SPECTRUM"

RALPH G. STEINHARDT, JR.
Lehigh University, Bethlehem, Pennsylvania

IT IS not often that science employs words defined primarily by implication. This, however, is the case with the word "spectrum" in contemporary physics and chemistry. Although we usually know reasonably clearly what *we* mean when we use the word in a particular connotation, we sometimes forget that others, whose training in science may be different from our own, may sense an alternative and possibly inconsistent implication. Furthermore, this lack of adequate definition has led to invalid (or, at least, untidy) usages of the word in non-physical fields. The bacteriological spectrum of the biologist and the political spectrum of the newspaper reporter are two examples of particularly annoying distortions of meaning. The word is used in so many different ways that its significance is becoming weakened with peripheral connotations of doubtful validity and questionable utility.

Various texts and references usually define "spectrum" reasonably satisfactorily, but do so restrictively. Thus, the definition given in a textbook on emission spectroscopy may or may not be applicable, for example, to a research aspect of spectrophotometry. This confusion is extended to almost all words using "spectrum" as their root. The Society for Applied Spectroscopy and the American Society for Testing Materials have taken note of this unfortunate state of affairs by rightfully omitting from their recent list of definitions[1] in the field of spectroscopy the following words, among others: spectral slit width, spectroanalysis, spectrophotometer, spectrometer, spectrograph, and spectrum. Although spectroscopy is defined as "the branch of physical science treating of spectra," it will be noted that this definition has little explicit significance as long as "spectrum" remains undefined. Thus, the Society for Applied Spectroscopy is placed in the somewhat embarrassing position of being unable to state precisely what it is for. The Society is clearly for something more than mere observation of spectra (whatever these may be). Yet its definition of spectroscopy implies only this, for its denotation of the suffix "-scopy" is "meaning observation, as in spectroscopy." It will be noted that this implication is different from the Society's explicit definition of spectroscopy as given above. (The difficulties of these highly regarded groups in reaching satisfactory definitions of the domains and tools of their activities dramatically indicate the considerable magnitude of the obstacles which may be encountered in the path toward clear and precise scientific nomenclature.)

The purpose of the present communication is to suggest possible descriptive definitions of "spectrum" and a few of the terms derived from or related to it.

It is felt that the primary source of confusion is the use of "spectrum" when "distribution" or "range" is meant; thus arise the unfortunate applications of the word in fields such as biology and journalism. In the physical sciences when a distribution involves energy as a range and intensity as a number it is recognizable as a spectrum. This basis for a definition extends itself to mass spectra by employing the Einstein equation, $E = mc^2$, thus recognizing that there is no real distinction between energy and mass. Relations involving intensity distributions of wave length are as simply clarified by using the equation $E = hc/\lambda$. On this basis the following definition of spectrum is suggested: A spectrum is any ordered relation between energy and intensity.

Another source of confusion is a result of the excessive restrictiveness with which the word "characteristic" is ordinarily employed. "Characteristic spectrum" has come to imply "electromagnetic radiation emission spectrum in the range 0.1 to 7000 Å. which is uniquely defined by the atomic number of the excited element." One who applies the term to the infrared absorption spectrum of water or to the mass spectrum of butane may be criticized for these usages. It is suggested, however, that these applications are valid. Any spectrum which is uniquely defined by the chemical characteristics of the excited substance may properly be called "characteristic."

Further difficulties in the field are encountered through the similarity of the words "spectrometer," "spectroscope," and "spectrograph." The suffix "-meter" properly refers to a device which makes a measurement, "-scope" to one which makes an observation, and "-graph" to one which makes a record of an observation or measurement. Unfortunately, "spectrometer" is usually used to name only electronic spectrometers; "spectroscope," optical spectrometers; and "spectrograph," photographic spectrometers. It is suggested that these and similar terms be employed in such a way as not to lead to inconsistent suffix usage. For example, a recording emission spectrometer is simply an emission spectrograph regardless of whether the recording is made photographically or through the use of electronic devices.

It is recognized that tradition often plays a large part in the process of definition. This is not objectionable only so long as no loss of meaning is introduced as the word matures. However, when the time comes that a word is weakened by retention of traditional and in-

[1] HUGHES, H. K. (Chairman), *Anal. Chem.*, **24**, 1349 (1952).

creasingly archaic usages as well as by awkward and invalid innovations, prompt and precise redefinition of the word is clearly necessary. It is felt that the suggestions given above may provide at least a foundation for necessary definitions and redefinitions in the field of spectroscopy.

WHY IS CHEMISTRY NOT TAUGHT IN MORE SCHOOLS?

JAMES W. KERCHEVAL
Iowa State Teachers College, Cedar Falls, Iowa

In a survey of science instruction in the public high schools of Iowa the question in the title, among others, was asked in a questionnaire sent out to 852 high schools. Replies were received from 390 of the senior high schools. Of these 139 offer chemistry every year or in alternate years.

The question as asked was: "If chemistry is not taught in your school, to the best of your judgment, what do you consider the three chief reasons for not offering it?" It was followed by a series of prestated answers that the writer felt most applicable to the situation in Iowa schools. The tabulated results from the replies of the 251 schools which do not offer chemistry are shown in the table.

Reason	*Number of schools selecting this reason*	*Per cent of the 251 schools replying*
There is no community demand for it	138	55
Too expensive to equip and provide laboratory	126	50
No room available	124	49
No qualified teacher to teach it	115	46
Not of sufficient practical value except as a college prep course	77	31
No time for it in the curriculum	56	22
The course is too expensive (chemicals and supplies)	43	17
It is not required for admission to college	28	11
Others	23	9

The reasons are arranged in the table in the order of the frequency of reply, not in the order as arranged in the questionnaire. However, the fact that the reasons were preformed in the questionnaire may influence the replies somewhat. It was felt in spite of this that the validity of the results from the above method would be better than that which would be obtained from the interpretation of subjective, written-in replies.

When the distribution of the replies was compared with the distribution of schools of different sizes throughout the state, it was apparent that the questionnaire was a truly representative cross section of the public high schools of Iowa.

Evidently some of the reasons why Iowa schools are not teaching chemistry are: (1) the parents and the students are not demanding it because they do not see sufficient practical or general educational value in it; (2) the school administration feels that it is too expensive to provide chemicals and equipment to offer such a course; (3) the school administration feels that a special room is needed for teaching chemistry; and (4) the school employs no one qualified to teach it.

If these are the true reasons, they are likely to be applicable to more than this one state, and they offer a challenge to those of us who believe that some chemistry is an essential part of every high-school curriculum. The problem is not insurmountable. The biggest job is acquainting the public with the important part chemistry plays in the lives of everyone and the consequent need for chemistry in the schools. That job involves the entire chemical profession. The next two difficulties can be solved if high-school teachers will abandon the idea that high-school chemistry must be taught as was their own college chemistry—the same subject matter, the same equipment. Those of us who are training high-school teachers have a heavy responsibility in this connection.

It should be possible, in the near future, to overcome the fourth difficulty in offering chemistry, unless an emergency further reduces the enrollment of students preparing to teach in the secondary schools. As interest in chemistry grows in the high schools, more students wishing to teach chemistry should enter our colleges and become available. At the present time many teachers capable of handling the course are teaching in schools where it is not offered. With a change in the demand they can fill the new immediate needs.

ACKNOWLEDGMENT

The writer wishes to acknowledge the help of Dr. H. M. Silvey of the Bureau of Research at Iowa State Teachers College in conducting the survey from which these data were obtained.

ATOMIC STRUCTURE AND THE PHOTOELECTRIC EFFECT

CLYDE P. BROCKETT
University of Toronto, Toronto, Canada

THE ubiquitous and inexpensive 110-volt, 2-watt neon glow lamp, General Electric NE-34, appears to have been overlooked as a device well suited to a brief but telling demonstration of a few key principles of atomic structure which underlie the study of electrovalence and comparative chemistry.

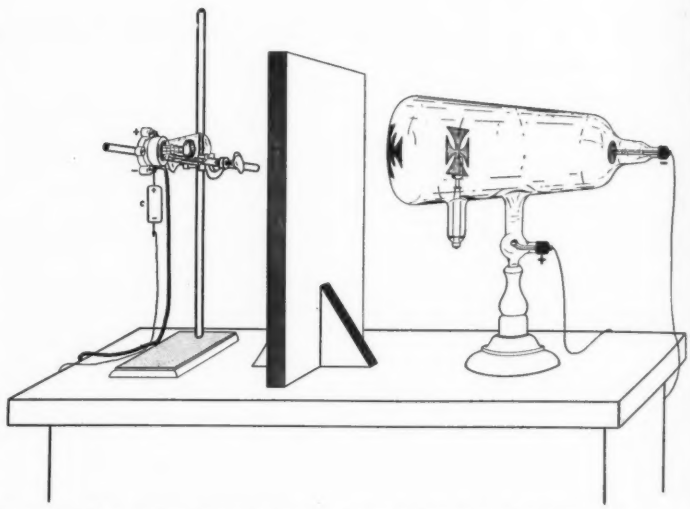

Figure 2. Photoelectric Demonstration, Using the 2-Watt Neon Glow Lamp as Phototube

WORKING PRINCIPLE

Nevertheless, when this lamp is supplied with a voltage only slightly below its ionizing threshold (*35*), the degree of photoemissive sensitivity, even to visible light, exhibited by its coated metal electrodes is gratifyingly useful; and its ready response to X-rays (*7*, *19*, *24*, *29*, *45*, *46*, *47*), as would be expected, makes it additionally attractive. In both cases ionization, hence conduction (*36*, *45*), is indicated by the abrupt appearance (*25*, *30*, *32*, *35*) of the self-sustaining (*37*) glow discharge, whose bright orange light is characteristic of neon at all but extremely high excitation frequencies. The lamp, thus utilized, serves as its own receiver, gaseous amplifier (*8*, *22*, *38*, *42*), and visual detector. Its simplicity and directness will appeal to the user; and the ease with which everyone can see the "end point" never fails to please a lecture-room audience.

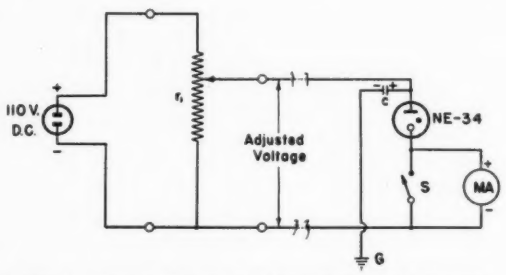

Figure 1. Circuit Diagram of Voltage Supply and Phototube

c 30-μf paper electrolytic, 150 volts. Trial will tell whether to connect it to the positive terminal of the neon lamp as shown, or to the negative terminal, as in Figure 2. (See text, for its function.)
*r*1 44 ohms, 3.1 amp., laboratory rheostat.
G Ground connection, to nearby water pipe.
S S.p.s.t. knife switch.
MA 0–25 ma. direct-current demonstration milliammeter (such as Cenco #82145).
. Extension leads, preferably short. (See comment on shielding in text.)

ADJUSTMENT

As indicated in Figure 1, a rheostat is connected as voltage divider, to supply an adjustable voltage. ARRL schematic notations (*3*) are employed in the circuit diagrams.

On direct current and in the dark, the lamp (Figure 2) lights at about 65 volts, its ignition potential (*37*), at which it at once passes 4 milliamperes, its threshold current (*36*). A very close approach to the ignition potential is required if the photoelectric capability of the lamp is to be realized. Referring to Figure 1, the recommended procedure is as follows:

(1) Do not remove the current-limiting resistor, which is inside the screw base of the lamp.

(2) Have the room completely dark, or only dimly lighted.

(3) By advancing the slider of the rheostat, increase the voltage gradually, starting at a low value, until the lamp suddenly lights. At this position of the slider put a stop or a mark on the slider bar.

(4) Reverse the motion of the slider at moderate speed, until the glow is completely extinguished (*39*).

(5) Advance the slider slowly again, as in (3) above,

to within just a shade less than its previous position. If the lamp lights, the slider has been moved too far and step (4) must be repeated.

(6) Repeat step (5), but advance the slider once again a little less than before, always trying to have the voltage nearly, but not quite, enough to start the glow.

DEMONSTRATIONS

(A). Once the lamp is brought by this stepwise approach to about the highest voltage it can take without lighting (*35*), it is in an essentially metastable, or sensitive, state and will now easily exhibit the photoelectric effect (*9, 17, 19, 24, 30, 34, 42, 45, 47*).

To show this, first point the beam of a sharply focusing flashlight (fresh batteries!) at the neon lamp, at close range: the lamp will light at once. Indeed, a little patient practice should soon make it regularly possible to trigger the lamp with the flashlight from a distance of at least 25 feet in a fairly dark room, providing the supply voltage is steady; or to do the same by simply turning the room lights on. The grounded condenser, *c*, although not indispensable, will stabilize the circuit enough to improve reproducibility quite noticeably.

This is an attractive demonstration of photoelectric emission and gaseous ionization; and it clearly and neatly frames the issues with a minimum of apparatus, there being no need of an external amplifier. Prepared in advance, with only the lamp and its support exposed to view, the experiment can be performed before an audience in less than a minute.

Results only slightly less favorable are possible if 110-volt, 60-cycle alternating current is used, instead of direct current. With this input the ignition voltage will be lower; and it will, of course, be necessary to do without the condenser, *c*, and its ground connection.

If it is of interest to make more of this demonstration, by amplifying the sensitivity of the neon lamp to its limit, see Special Operating Notes below.

(B). Further aspects of atomic structure may be illustrated with the aid of a Hittorf cathode-ray tube, energized by predominantly rectified (*4*) high voltage directly from an induction coil. In the vicinity of the shadow end of the tube (Figure 2), the sensitive lamp will light, under the ionizing power of the X-rays from the tube, the moment the induction coil is turned on (observe high-voltage polarities). Indeed, the lamp at the proper voltage acts as a sensitive detector of X-rays, thanks to the abundant ionization they cause. Repeating the experiment with a thick wooden board between the tube and the lamp, or enclosing the tube within a heavy wooden box, will perhaps heighten the effect; but, more importantly, it is likely to add unforgetable point to some of the pertinent principles of atomic structure being illustrated. Interposing a sheet of lead, hung on the board, will attest (*46*) to the high atomic number of lead as the X-rays, no longer reaching the lamp, fail to light it.

Radiation from the high-voltage leads to the Hittorf tube is easily able to induce sufficient voltage in the leads to the neon lamp to cause the lamp to light, whether there is any X-ray generation or not. A valid demonstration therefore demands that the connections to the neon lamp be within braid shielding that is well grounded. This precaution may apply with equal force to (E) below.

(C). A demonstration type, or projection type, milliammeter of low range may be used to advantage, if it is desired to dispel all doubt that ionization, initiated by the photoelectric effect, results in gaseous conduction, timed with the neon glow. When the meter is not used, switch *S* is left closed.

(D). If the neon lamp, readied as in (A), is illuminated by the flashlight beam from the side, rather than from the front, it can be shown that the site of the photoelectric sensitivity to visible light is at, or within (*30*), the surface of the electrodes instead of in the neon itself. Simply shade the electrodes, allowing the light beam to pass transversely through the forward part of the bulb, and the lamp remains dark. Then slowly retract the shade, until direct illumination reaches the electrodes: the lamp lights promptly. The fact that metals surrender electrons with relative ease (*48*) is thus rendered obvious in a most convincing manner.

(E). A collimated beam of X-rays, an inch or two in diameter, when passed through the gas in the sensitive neon lamp without impinging on the electrodes, will cause ionization of the gas itself and light the lamp. This, contrasting with the observations on visible light in (D) above, furnishes evidence of the high energy of X-ray radiation, reminiscent of the quantum-theory relationship:

$$E_2 - E_1 = \frac{hc}{\lambda}$$

EXPERIMENTAL

The neon lamp, very close to its ignition potential in the dark, is extraordinarily responsive to external electric fields, the static charge produced by merely lifting a 3 × 5 in. glazed porcelain plate from the dry surface of a previously oiled wooden table top at a distance of two or three feet from the lamp and its connecting leads having been repeatedly found sufficient to trigger the glow.

In fact, stray charges, cosmic rays, localized potentials on the glass surface (*43*) of the lamp, thermal noise level, fatigue effects (*45*) from condensation of the neon on the electrode surface (*8*), adsorption or release of gas by the glass envelope (*44*), and minute supply-voltage variations, may individually or in combination sufficiently vie with the signal itself, when the lamp is barely short of lighting, to give rise to erratic photoelectric performance . . . which it is then best to view in private.

On the other hand, reliable photoelectric response, so essential before an audience, is easily assured by maintaining the neon lamp at something rather lower than its

spill-over voltage. It is with confidence that the flashlight may then be handed to a front-bencher for audience participation.

SPECIAL OPERATING NOTES

(1) The more the supply voltage fluctuates, the more it is certain to mar attempts to show how greatly it is possible to magnify the photosensitivity of the neon lamp. It is then that some form of voltage stabilization will be required (*1, 11, 31, 33*), usually calling for a radio-receiver type power supply, operating on 110 volts a. c.

(2) If a 110-volt d.-c. lighting service is available, whose voltage variations are only moderate, a sufficient degree of stabilization may be had for excellent performance of the neon lamp as phototube, by using a VR-75 glow-regulator tube in the circuit of Figure 3. This arrangement, all mountable on a small metal chassis or even Masonite panel, permits a micrometer approach (r_4) to the ignition point of the lamp and has made it regularly possible to trigger the glow with the flashlight from a distance of 60 feet. It should be emphasized that the variable resistor, r_4, must be a wire-wound unit, if such results are to be expected, since the carbon type resistor of $^1/_2$ watt or 1 watt rating is not stable enough.

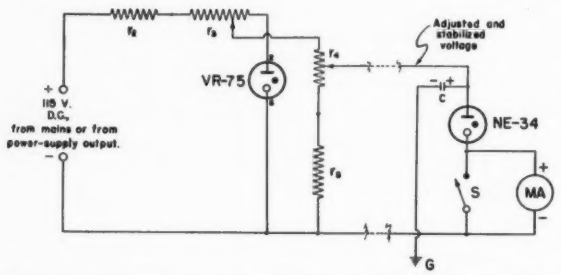

Figure 3. Circuit Diagram of Stable Voltage Supply, with Phototube

r_2	5000 ohms, wire-wound.
r_3	2000 ohms, wire-wound, with adjustable tap at about 1500 ohms.
r_4	5000 ohms, wire-wound potentiometer (such as IRC volume control, # W-5000).
r_5	0.1 megohm, 1 watt.
c	30-μf. paper electrolytic, 150 volts.
G	Ground connection, to nearby water pipe.
S	S.p.s.t. knife switch.
MA	0–25 ma. direct-current demonstration milliammeter.
. . .	Extension leads, preferably short. (See comment on shielding in text.)

If the circuit of Figure 3 is connected to a d.-c. lighting service, whose voltage is much above 105 or 110, its output voltage will probably always exceed the ignition point of the neon lamp. To correct this, supply this circuit from the adjustable-voltage output of the Figure 1 circuit.

By supplying the circuit of Figure 3 with 110-volts d. c. from an electronically stabilized power supply operating on 110-volts, 60-cycle, a. c. (*2, 12, 23*), whose voltage is maintained extremely constant, the photosensitivity of the neon lamp has been sufficiently enhanced to permit lighting the lamp by flashlight from a distance of 100 feet, with good reproducibility. Performance of that order is improbable unless all connections possible are soldered, conforming to universal practice in electronics; and shielding the leads to the lamp, with the shielding grounded (*G*, Figure 3), is almost a necessity.

(3) The use of batteries (90 v. + 22.5 v.) as input to the Figure 3 circuit is likely to be only partially successful.

(4) Since not all NE-34 lamps are equally photosensitive, choosing one from among a number of them may be very well worth while. Only those lamps should be considered whose two semicircular electrode surfaces appear flat and strictly co-planar.

(5) Because the glow discharge is evidence of several concurrent phenomena, it should be interpreted with care, even to the extent of making it clear to the student that the light is not the photoelectric effect *per se*, but its end result. And the beginner must not be led to suppose that the apparatus described here lends itself to quantitative measurement of, for example, minimum ionization potential (*6, 8, 10, 14, 18, 20, 21, 27*).

(6) If the sheet lead, Demonstration (B), is not connected to a good electrical ground, neither the intended effect nor the argument can amount to much.

(7) The argon-filled lamp, AR-1, is apparently much less photosensitive than the NE-34 lamp.

(8) CAUTION: The probability that exposure of the body to the X-ray radiation from a particular Hittorf tube, or other unshielded high-vacuum cathode-ray tube operating at high voltage, is harmless over a period of time should not be lightly assumed.

SUMMARY

The NE-34 cold-cathode gas diode, used as phototube, becomes a simple, rapid, and direct aid to descriptive study of atomic structure by lending persuasive reality to several phenomena:

Photoelectric emission from metals (*24, 30, 42, 47*).
The (Townsend) ionization avalanche (*20, 22, 25, 35, 37*).
Gaseous conduction (*13, 26, 36, 45*).
Re-combination of ions (*5, 13, 16, 40*).
Minimum ionization potential (by analogy) (*41*).
Generation of X-rays by high-speed electrons (*15, 19, 28, 29*).
Penetration of X-rays through solids, whose chemical elements are of relatively low atomic number (*46*).

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ON COMPRESSION WORK

WILLIAM M. SPICER and JACK HINE
Georgia Institute of Technology, Atlanta, Georgia

In a widely used textbook of chemical thermodynamics there appears a statement implying that the work required to compress an ideal gas adiabatically from P_1 to P_2 is always less than that required for carrying out the analogous isothermal process. Private inquiry revealed that this opinion is shared by many students and instructors in thermodynamics, and no statement to the contrary was found in any of the textbooks available.

It is the purpose of this article to show that this is not true as a generalization, and to show further the conditions under which it is and is not correct. It will be shown that whether the isothermal or adiabatic compression requires more work, although independent of the initial temperature, depends on the ratio by which the pressure changes.

At first thought it may seem reasonable that the adiabatic compression should require less work than the isothermal, since, because of the temperature increase in the adiabatic case, the final volume is greater and hence the change in volume is less than for the isothermal process. However, the amount of work done obviously also depends upon the exact manner in which the pressure changes. Calculations show that the average pressure in the adiabatic is higher than in the corresponding isothermal compression. Thus we have two opposing factors. At lower values of P_2/P_1 the larger volume change accompanying the isothermal compression is the more important factor, while at higher values of P_2/P_1 the higher average pressure in the adibiatic compression predominates. This can be shown by Figure 1, which is a P-V diagram for the compression of one mol of a perfect monatomic gas initially at one atmosphere and 25°C. Notice that for a final pressure of four atmospheres the volume in the adiabatic case has decreased to only 10.65 liters, while in the isothermal case it has decreased to 6.12 liters. Notice, however, that the average pressure is higher for the adiabatic compression. The work required, represented by the area under the curve, is 33.91 l.atm. for the isothermal and only 27.20 l.atm. for the adiabatic. On the other hand, for compression to 25 atmospheres more work is required for the adiabatic than for the isothermal, as shown by the shaded areas. The

figures are 96.30 l.atm. and 78.78 l.atm., respectively. For a gas of this type the "cross-over point" where the same amount of work is required for each type of process occurs in compression to 10.7 times the original pressure. The value of P_2/P_1 at the "cross-over point" varies gradually with the heat capacity of the gas, becoming less as the heat capacity increases. From the value of 10.7 for $C_v = 3/2\ R$, it decreases to 9.6 for $C_v = 5/2\ R$, and to 8.6 for $C_v = 8/2\ R$. At an infinite value of C_v the two curves merge, of course, since under this condition the adiabatic process would also be isothermal.

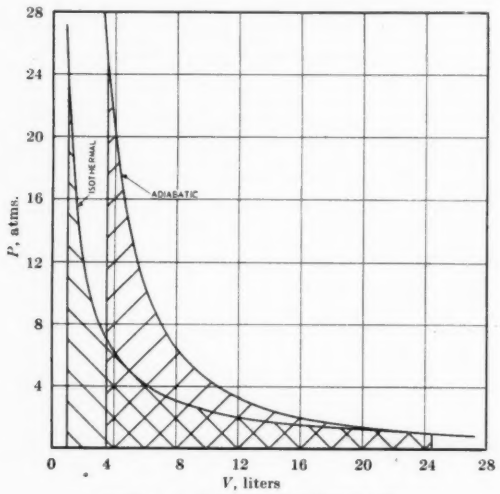


Figure 1. *P-V* Curves for a Perfect Gas

It might be instructive to calculate the work in another way. For a reversible change in pressure of a mol of a perfect gas, the work done by the gas in the isothermal expansion is

$$w_I = RT_1 \ln \frac{P_1}{P_2} \qquad (1)$$

and in the adiabatic expansion is

$$w_A = C_v T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{R/C_p}\right] \qquad (2)$$

Subtracting (2) from (1), we obtain

$$w_I - w_A = T_1 \left[R \ln \frac{P_1}{P_2} - C_v + C_v \left(\frac{P_2}{P_1}\right)^{R/C_p}\right] \qquad (3)$$

If $P_2<P_1$, *i. e.*, if the gas is expanded, it can be shown that the right hand of equation (3) is positive. This means that the gas always does more work in the isothermal expansion. This is shown in Figure 2, which is a plot of w/T_1 versus P_1/P_2 for a monatomic gas.

The work which must be done on the gas to bring about a given pressure change reversibly, represented below by W, is, of course, the negative of that done by the gas (equation (3)), and thus

$$W_I - W_A = T_1 \left[R \ln \frac{P_2}{P_1} + C_v - C_v \left(\frac{P_2}{P_1}\right)^{R/C_p}\right] \qquad (4)$$

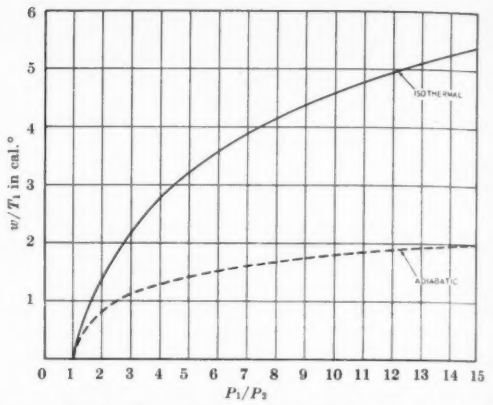


Figure 2. Work of Expansion of a Mol of a Perfect Monatomic Gas

Notice that the difference, $W_I - W_A$, is proportional to T_1 and notice, too, that its sign is not affected by T_1. As mentioned above, for compression ($P_2>P_1$) the right hand side of equation (4) is positive for lower values of P_2/P_1 and negative for higher values. This is clearly shown in Figure 3, which is a plot of W/T_1 versus P_2/P_1 for a monatomic gas.

In comparing Figures 2 and 3, it is interesting to note that the isothermal work is similar in expansion and compression, but there is no similarity in the adiabatic cases. The work done in an adiabatic expansion rapidly approaches a limit as P_1/P_2 increases. This is not surprising, since the work done in an adiabatic expansion is done entirely at the expense of the internal energy and is therefore limited to the initial value of the internal energy of the gas (C_vT_1). On compression the work increases rapidly and without limit.

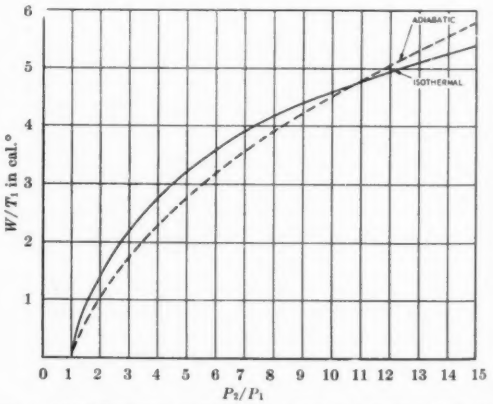


Figure 3. Work Required to Compress a Mol of a Perfect Monatomic Gas

It should be pointed out that in engineering calculations of work of compression where "flow work" is taken into account, the work required for the adiabatic is always greater than that for the isothermal process, regardless of the value of P_2/P_1.

MOLECULAR MODELS FOR LECTURE DEMONSTRATIONS IN ORGANIC CHEMISTRY[1]

FRANK L. LAMBERT
Occidental College, Los Angeles, California

THE use of molecular models in lecture demonstrations of organic chemistry has presented a problem to many instructors. There is general agreement that such illustrations are useful, although admittedly the instructor who uses only this type of demonstration has a barren repertoire. For most small classes the Brode-Boord-Hurd ball and peg models[2] are quite satisfactory to show basic connectional relationships. At Occidental College we have found it helpful to purchase 15 sets together with additional individual atoms[3] and to build "permanent" models of the substances to be illustrated during the lectures of the year. (It probably need not be emphasized that this was an evolutionary process.) These stock models, placed in adequate boxes according to lecture subject, can be taken to the lecture room when needed without the necessity of hurried pre-lecture construction or modification. Also, small bottles of reagents used in the particular lecture demonstration can be included in the boxes.

Little justification is necessary for the maintenance of an ample supply of permanent models for display or illustration of reactions. The time which is saved by the instructor is obvious. Moreover, when there is any confusion in the student's mind regarding a model shown to him, it is certainly not decreased by the instructor's rapid dismantling of the model to build another. If this procedure is followed, the student may sadly watch the fragments of what he had almost understood materialize into something new and equally tormenting. This certainly does not mean that changes and reactions should not be illustrated with models. However, beginning students in organic chemistry might agree that many instructors blur the clear picture they are trying to create whenever they use models to illustrate reactions. We feel that in such cases there should be two or more models of the starting material on the lecture table so that one will remain unaltered as a firm point of reference for the student.

The commercially available ball and peg models are not too satisfactory for large lecture classes, nor do they give indication of the sizes of the spheres of influence of the individual atoms. The latter objection is quite adequately eliminated in the Fisher-Hirschfelder-Taylor models,[4] but their small size makes them unsuitable even for rather small classes unless the group is gathered around the instructor. Nicholson,[5] in an excellent review of molecular models, has mentioned several lecture-size developments including Quill's ball and peg models employing croquet balls, Shriner's large wooden tetrahedra, and Campbell's[6] and Dutton's wooden models which resemble the Fisher-Hirschfelder-Taylor models but on a scale of one inch to one Ångström. On several occasions Pauling and Corey have exhibited elegant research models employing wooden balls with such refinements as adjustable hydrogen atoms whose bond angles can be altered without affecting their connection to other atoms. There are probably many other individual solutions of the problem but, perhaps like the majority of the foregoing, either they require a great deal of time in their preparation or are somewhat expensive if a library of several dozen models is to be built.

After considering several unprofitable systems using elements varying from ping-pong balls to practice golf balls, Dr. L. Reed Brantley of this institution began last year the use of Styrofoam plastic balls in his inorganic chemistry classes. The author has found them eminently suited to organic chemistry because of their relatively low cost, their ease of fabrication, and the availability of sizes which roughly correspond to the most common atomic volumes. The Stuart-type models[7] constructed from Styrofoam on a scale of one inch to one Ångström are currently being used to supplement the commercial ball and peg models in the organic chemistry lectures.[8] Modification has been made in benzenoid, ethylenic, and acetylenic carbon atoms to indicate the presence of π electron orbits in the completed molecules.

Judging from the large photographs in several recent texts, one might conclude that presentation of a Stuart

[1] Presented at the 123rd Meeting of the American Chemical Society, Los Angeles, California, March, 1953.

[2] BRODE, W. R., AND C. E. BOORD, J. CHEM. EDUC., **9**, 1774 (1932). Commercially available as item S-61815 from E. H. Sargent and Co., Chicago, Ill.

[3] The number is arbitrary, of course. Perhaps about ten sets would be an optimum quantity, and additional carbon atoms might be purchased in dozen or six dozen lots if desired. It is our regular practice to keep at least one complete kit of individual atoms always on the lecture table to illustrate unanticipated student questions. We have not followed Brode and Boord's excellent suggestions regarding systematic use of the models in laboratory instruction but we have several kits for loan to students for home or laboratory use.

[4] Available as item 12-821 from the Fisher Scientific Co., Pittsburgh, Pa. Catalin, Inc., is manufacturing a similar set in England from plastic atoms with flexible connectors.

[5] NICHOLSON, D. G., *Chem. Eng. News*, **30**, 3164 (1952).

[6] CAMPBELL, J. A., J. CHEM. EDUC., **25**, 200 (1948).

[7] STUART, H. A., *Z. Phys. Chem.* (B), **27**, 350 (1934).

[8] If Styrofoam plastic balls are to be used in permanent large ball and peg models, the pegs can be constructed from methacrylate rod and the pegs fastened with polystyrene cement. We have not found such models very useful because the rods provide great leverage for enlargement of the holes.

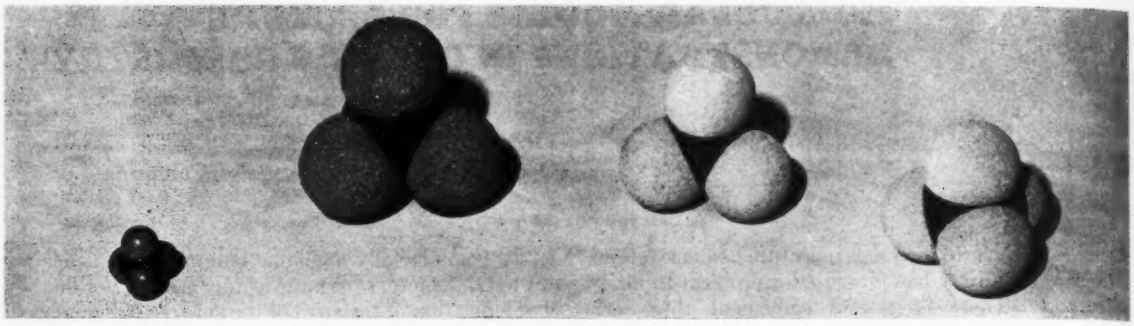


Figure 1. A Fisher-Hirschfelder-Taylor Model of Methane; a Lambert Model of Methane (Scale = 1.1 Inch to 1 Å. C—H Distance = 1.35 Inches); a Later Model of Methane (Scale = 1 Inch to 1 Å. C—H Distance = 1.2 Inches); Current Scale Model of Methane (Scale = 1 Inch to 1 Å. C—H Distance = 1.0 Inch)

type of model for a given class of compounds is a major part of the exposition of the chemistry of that class. Useful as our models are, we consider them as no more than adjuncts to the lecture! Moreover, we have found that the Stuart models have severe limitations. They convey a great deal of information in the simpler molecules to all levels of students. From more complex molecules the advanced student can gain an equally great amount of information regarding the space occupied by the whole molecule, relationships between groups, and the like. Unfortunately, the beginner who sees a polysaccharide or polypeptide for the first time may be more confused than enlightened. To decrease such confusion our first presentation of a complicated structure to a class is always prefaced by the statement that one should not expect to see more than the general outline of the repeating unit. The average student is urged to learn the blackboard formulas thoroughly before trying to interpret the models.

In our early work the covalent bond distance of the hydrogen atoms was made equal to 0.5 inches instead of 0.3 inches, in order to permit a good meeting of the carbon and hydrogen atoms without hand-tapering of the edges of the hydrogen cut faces. Although this is a very large percentage error (other inaccuracies in these models are not greater than 10 per cent) and although the difference is visible, it introduces little specious steric hindrance in simple alkane molecules. In Figure 1 is shown a Fisher-Hirschfelder-Taylor model of methane in comparison with some of our own models on different scales. In Figure 2 are shown relative sizes of carbon atoms. Other alkanes and simple aliphatic molecules are shown in Figure 3. β-D-glucose and a short length of the cellulose molecule (Figure 4) illustrate the limitations of this type of model; lack of color in the reproduction makes identification of atoms even more difficult, of course. The $—CH_2OH$ group projecting above the plane of the unit toward the rear in alternate molecules can be discerned without too much difficulty. The oxygen atoms in Figure 4 also were early productions and the oxygen atoms were made of $2^1/_2$-inch rather than $2\ ^3/_4$-inch balls. Nevertheless, the covalent bond is equal to 0.7 inches and less specious steric hindrance seems to be present with these $2^1/_2$-inch balls for oxygen. In Figure 5 are shown aromatic molecules and a portion of a polyacrylonitrile chain.

One large scientific company was approached regarding commercial manufacture of this type of foam plastic models, but their conclusions were that the process would be too expensive on a commercial basis. With inexpensive student aid or free professorial labor the plastic atoms are quite reasonable and it is hoped that the details of construction given here will reduce the development work of other instructors. Styrofoam balls are commercially distributed as Christmas-tree ornaments and are probably available in many localities from novelty jobbers. The most uniform and cheapest balls were obtained from an Eastern fabricator of Dow

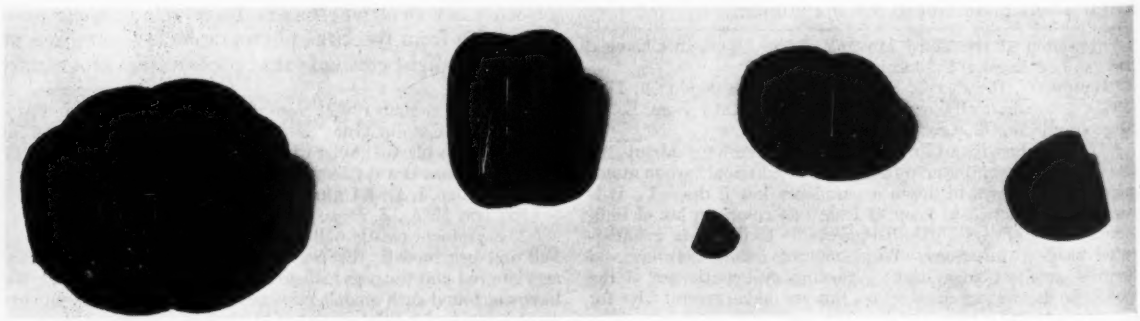


Figure 2. A Benzene Ring, an Acetylenic Unit, a Fisher-Hirschfelder-Taylor Tetrahedral Carbon, an Ethylenic Unit, a Tetrahedral Carbon

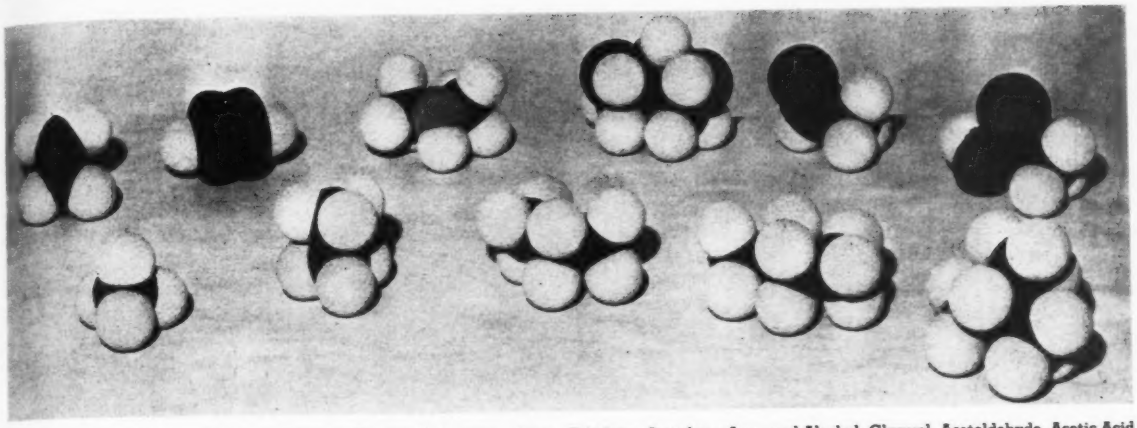


Figure 3. Front: Methane, Ethane, Propane, Butane, Isobutane. Rear: Ethylene, Acetylene, Isopropyl Alcohol, Glycerol, Acetaldehyde, Acetic Acid

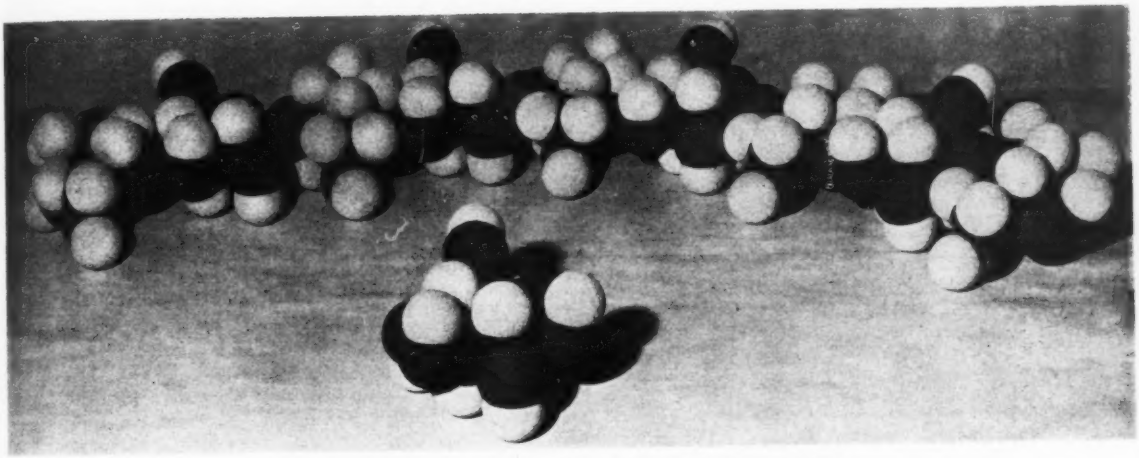


Figure 4. Front: β-D-Glucose. Rear: Cellulose (95-D-Glucose Units)

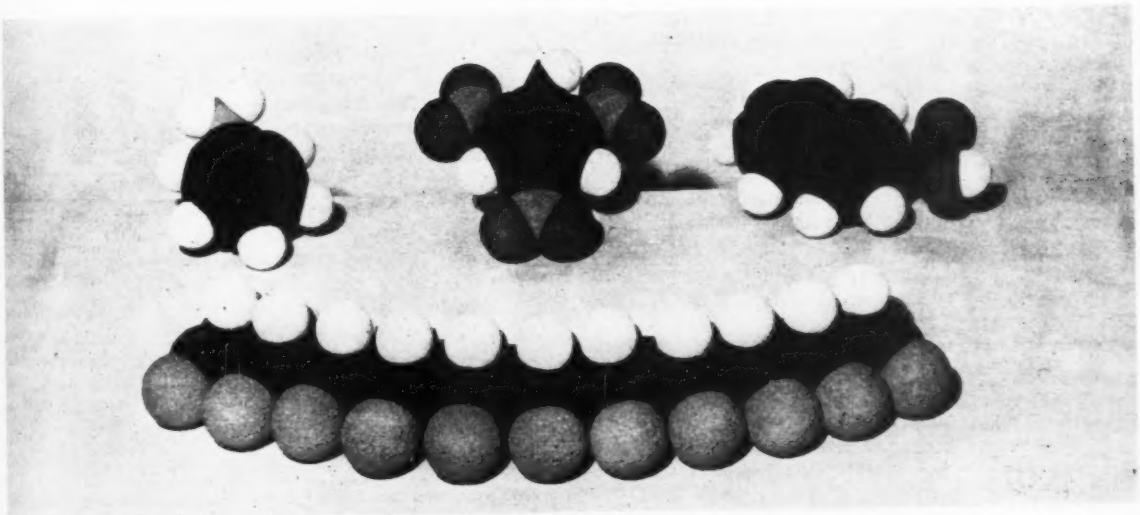


Figure 5. Front: Polyacrylonitrile. Rear: Aniline, 2,4,6-Trinitrotoluene, β-Naphthoic Acid

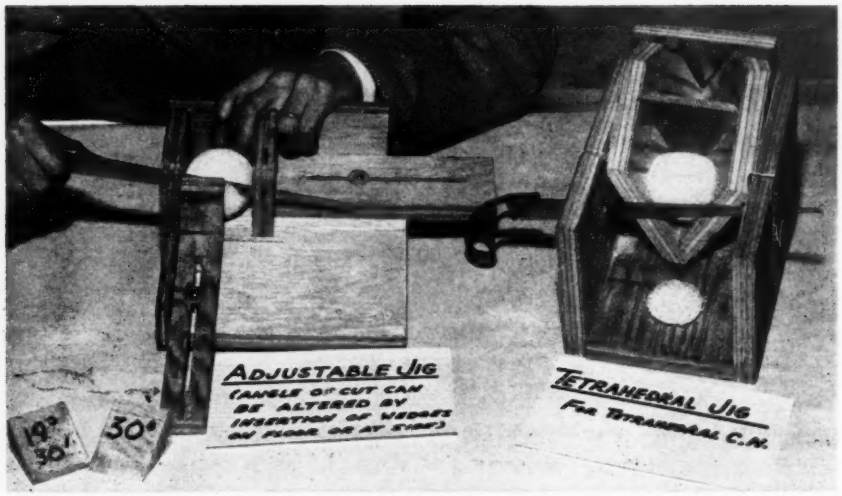


Figure 6. Jigs Used for Shaping Atoms

Styrofoam.[9] Costs range from \$3.60 a gross for balls of $2^1/_4$-inch nominal diameter to \$1.30 a dozen for the 4-inch nominal diameter size. If $2^1/_4$-inch balls are used for hydrogen, the $2^1/_2$-inch for tetrahedral carbon, and the $2^3/_4$-inch for oxygen and nitrogen, the effective atomic diameters are on a scale of about 1 inch to 1 Ångström. A suggestion by Dr. R. B. Corey of the California Institute of Technology that the benzenoid and ethylenic carbons should be somewhat larger to indicate π electron orbitals has been incorporated by using the $3^1/_2$-inch balls for benzenoid and acetylenic carbon and the 3-inch for ethylenic carbon atoms. Even though realism is desirable, scraping of contiguous atoms and some unreal steric hindrance may be eliminated if the oxygen and nitrogen are reduced to $2^1/_2$ inches and acetylenic carbon to 3 inches. The other technique of avoiding such hindrance, carving the sides of interfering atoms, is a bit laborious.

Because polystyrene is a thermoplastic, heat-forming and sealing were first tried as methods of fabrication of the individual atoms from the Styrofoam balls. This technique was fast but it resulted in crude and variable products. Nevertheless, it is a bare possibility that a heating process might be successfully used if several hot plates were arranged at the proper angles and care were exercised not to shrink the balls unduly.

Our present technique for "atomic syntheses" consists of cutting the balls in the jigs shown in Figure 6.[10] A hacksaw blade or sharp knife can be used to slice the balls cleanly. Even though a tetrahedral carbon atom could be cut in the adjustable jig, the last two cuts involve visual estimation for placing the atom and therefore a special jig was made for these cuts on carbon and nitrogen. Basically, it is a trough (with sides forming an angle of 71°) fitted with a backstop for holding the half-formed carbon atom. The trough is inclined at an angle of 19° to the floor.

More tedious than the cutting of atoms is the technique of tapering atoms other than carbon so that the cut faces will have the same diameter as the carbon faces. Use of a standard buffing wheel produced worse results than hand smoothing and we did not design a concave curved buffer. (None was available commercially.) Instead all grinding is done by roughing down the face edges with very coarse grit paper and then rubbing them with another piece of Styrofoam.

Coloring of the Styrofoam was considered to be a major problem when the first dyes used resulted in faint pastel colors. However, spraying with ordinary or Siliconized enamel gives a brilliant finish without undue dissolving of the plastic. Rubber-base paints are very satisfactory, as might be anticipated. They do not produce a shiny product but they can be applied in thick coats and actually make the atoms more resistant to impact damage. If enamels are to be used, high concentrations of ester or petroleum solvents must be avoided because softening of the Styrofoam occurs. One batch was spoiled by allowing the atoms to dry while standing on a paper surface; evaporation was retarded and the solvent was retained by the paper long enough to soften the edges of the cut faces. Obviously, air movement aids drying and helps to prevent any such softening of the atoms.

Permanent models are easily made by applying a resin glue or a small quantity of a cement made from the polystyrene scraps dissolved in a minimal amount of carbon tetrachloride or benzene. We believe it useful to prepare —CH—, —CH_2—, —CH_3, —OH, —COOH and similar units as permanent building blocks to expedite preclass or classroom construction. Rotatable and temporary bonds can be formed by using pipe cleaners as connectors.[11] The best type of pipe cleaner has rather long rayon fibers rather than the tightly bound cotton chenille present in smokers' pipe cleaners. This is not a petty detail because it has been found that the long-fiber cleaners form very strong bonds, once they have been inserted in the atoms. If carefully in-

[9] Star Band Company, Broad and Commerce Streets, Portsmouth, Virginia. The balls supplied are one-eighth to one-quarter inch smaller than the nominal size, but are relatively smooth and round compared to products of local suppliers. This firm does not manufacture $2^3/_4$ or $3^1/_2$ inch balls at present but might do so if enough demand were present. The 4-inch ball seems to be hand finished and is actually about $3^3/_4$ in the shipments we have received.

[10] The adjustable jig was designed by an alert freshman, Mr. Leland Marple.

[11] Perhaps the name of a supplier may be obtained from the Star Band Company since the Styrofoam snow-balls are supplied to the Christmas trade with such cleaners inserted as holders.

serted in the same hole, they can readily be removed and replaced at least a hundred times without coming loose or enlarging the hole. In contrast, ordinary pipe cleaners enlarge the holes rather rapidly.

Perhaps one word of caution in regard to handling the models is needed. These models are not delicately fragile but they are not rugged enough to be passed around the class. Dismantling and construction in the hands of the instructor or careful assistant will not hurt them. Occasional falls on the floor dent but do not destroy them. Nevertheless demonstration of free rotation by a ruthless student will rapidly remove the top layer of paint and make them look atomic-moth eaten.

There is, to be sure, no reason why our variety of molecular model could not be made in larger sizes for extremely large classes. The plastic balls are commercially available in diameters up to 6 inches and larger sizes might be produced. We have done no development work on the interesting possibility of forming the polystyrene foam in molds of the shape of individual atoms or of the benzene ring, because the local office of Dow Chemical Company advised us that they had never been successful in filling molds by formation of the Styrofoam *in situ*. It should be tried.

We feel that these plastic models, regardless of future developments and despite some inherent limitations, are a convenient and useful addition to the lecture demonstration equipment of organic chemistry.

A HOME REFERENCE LIBRARY FOR CHEMISTRY STUDENTS

GERALD JAHODA
University of Wisconsin, Madison, Wisconsin

BECAUSE of the vast accumulation of data, today's student of chemistry must rely on the literature more than ever before. It is therefore to his advantage to become acquainted with the organization and proper use of the chemical literature at the earliest possible stage of his training. A good way of helping him to accomplish this in an informal fashion is to encourage him to acquire for his own collection a core of reference books. A great number of undergraduate as well as graduate students are not aware of the wealth of information available in basic reference tools such as dictionaries and handbooks, simply because they are not in the habit of regularly consulting them. By owning a number of these relatively inexpensive reference tools, the student will have a great deal of information at his fingertips, and through constant use of it will develop good library habits which will not only benefit him throughout his professional career but also reduce his tendency to memorize material which he can readily obtain from these books. The present article contains an annotated list of dictionaries, guides to the literature, handbooks, and aids for report writing and literature searches. The lower-priced books have been chosen with the student's limited budget in mind. This would naturally exclude encyclopedias, abstracts, indexes, etc., which are a part of every technical library's basic collection. In our opinion the student will make better use of these comprehensive tools after developing the habit of going to his own reference books for information.

DICTIONARIES

General: Aside from its common function of definition, a dictionary may have one or more of the following features: pronunciation of words, lists of abbreviations, grammatical aids, style manuals, biographical and geographical data, and synonyms and antonyms (important for getting subject headings in literature searches).

"Webster's New Collegiate Dictionary," G. and C. Merriam Co., Springfield, Mass., **1949**, $5.

Webster's dictionary has all of the above features. New words and foreign words and phrases have been revised from the 1936 edition, so that this dictionary is useful for short, up-to-date definitions of technical terms.

"Merriam-Webster's Pocket Dictionary," Pocket Books, Inc., New York, **1947**, $0.35.

Issued by arrangement with the publishers of Web-

ster's New Collegiate Dictionary, this volume is smaller in size and less comprehensive in coverage (25,000 entries as against 125,000) and without the encyclopedic features of the collegiate dictionary, except for lists of abbreviations and sizes of cities.

Chemical: Chemical dictionaries describe or briefly define compounds, laws and theories, reactions, instruments, and apparatus in chemistry and related fields.

"Hackh's Chemical Dictionary," 3rd ed., The Blakiston Co., Philadelphia, **1944**, $8.50.

This volume contains brief definitions of chemical terms, and is fully illustrated with charts (*e. g.*, industrial gases, electromagnetic radiations, indicators), description of elements, compounds, minerals, drugs, animal and vegetable products. There are also drawings of chemical instruments and apparatus, and portraits and brief biographical sketches of prominent chemists.

"Condensed Chemical Dictionary," 4th ed., Reinhold Publishing Corp., New York, **1950**, $12.

The emphasis here is on substances with commercial importance. A feature of this dictionary is a list of chemicals by trade and brand names, with name of manufacturer. For important compounds, the physical properties, derivation, impurities, grades, containers, uses, caution, and shipping regulations are given.

These are but two examples of the half-dozen or so chemical dictionaries which are currently on the market. The former covers a broader field of the science, and gives longer definitions. The latter stresses applied chemistry, and is useful for identifying compounds known only by trade names.

Bilingual Technical Dictionaries: A large portion of the literature is written in foreign languages, German and French being the most important ones, with Russian constantly becoming more significant. A good technical dictionary should contain the following features: up-to-date technical terms in chemical as well as related sciences, a basic general vocabulary, a brief introduction to the grammar, and an explanation of the system of alphabetizing.

PATTERSON, A. M., "A German-English Dictionary for Chemists," 3rd ed., John Wiley & Sons, Inc., New York, **1950**, $5.50.

Patterson has all of these features. There are over 59,000 terms, including a list of abbreviations interfiled alphabetically. In many instances, the science in which the word is used is indicated. In addition to pure and applied chemistry, Patterson also covers important terms in related sciences. In the introduction, a large number of other German-English, English-German technical dictionaries, which will be found in most large libraries, are mentioned.

DE VRIES, L., "German-English Science Dictionary for Students in the Agricultural, Biological, and Physical Sciences," 2nd ed., McGraw-Hill Book Co., Inc., New York, **1946**, $5.

This dictionary covers a broader range of the sciences and is therefore not as inclusive for chemical terms.

PATTERSON, A. M., "A French-English Dictionary for Chemists," John Wiley & Sons, Inc., New York, **1921**, $4.50.

This work is by the same author as the German-English dictionary, although it is not as up to date as the latter.

DE VRIES, L., "French-English Science Dictionary for Students in Agricultural, Biological, and Physical Sciences," 2nd ed., McGraw-Hill Book Co., Inc., New York, **1951**, $6.50.

Again, this is not exclusively devoted to chemistry, but is more up to date in terminology than Patterson. It contains a list of other French-English, English-French dictionaries for further reference.

HANDBOOKS

Handbooks contain a large amount of useful information which may be either of a general nature (*e. g.*, World Almanac) or pertaining to a special subject (*e. g.*, Handbook of Chemistry). Data on a variety of subjects is conveniently assembled in one volume, making the information readily available. Since all this information is copied from another source, errors occasionally occur, and, in the case of chemical information, the data are seldom up to date. It might be pointed out that one cannot make a literature search merely by consulting a chemical handbook, and that the information contained therein should be evaluated with its limitations kept in mind.

General:

"World Almanac and Book of Facts," World Telegram and Sun, New York, yearly, $1.10.

The material covered by the Almanac ranges from important historical dates since 4,004 B.C. to vital statistics about Miss America. Topics of more pertinent interest to chemists are Nobel Prize winners, American Chemical Society awards, U. S. patent and trade mark laws, mean temperature and precipitation in the United States, and average wholesale prices for chemicals 1920–51, among others.

Chemistry: The two major handbooks in chemistry are:

LANGE, N. A., "Handbook of Chemistry," 8th ed., Handbook Publishers, Sandusky, Ohio, **1952**, $7.
"Handbook of Chemistry and Physics," 33rd ed., Chemical Rubber Co.. Cleveland, Ohio, **1951**, $7.50.

Both of these include tables of physical properties of compounds, glossaries of technical terms, laboratory formulas and recipes, first aid directions, tables of hazardous chemicals, specific gravity of aqueous solutions, trade names of chemicals, and mathematical tables. Lange gives references to Beilstein for organic compounds, has an outline of qualitative analyses based on H_2S separation, a list of organic solvents arranged in the order of their boiling points, a dilution table for volumetric solutions, and a list of volume numbers and years for important chemical journals. The "Chemical Rubber Handbook," as the "Handbook of Chemistry and Physics" is commonly called, has more mathemati-

cal tables, physical constants of metal-organic compounds, and, in general, more data on physics.

ATLASES

Although chemists are seldom called upon to use atlases in their professional work, a recent inexpensive pocket book edition of high quality seems worth mentioning:

Rand McNally's Pocket World Atlas, Pocket Books Inc., New York, **1951**, $0.35.

This atlas, issued by one of the best U. S. atlas publishers, has many of the features of a regular-sized atlas, although a reading-glass is sometimes necessary to discern the fine print. There are 174 pages of maps, some of them in full color, with an index to cities and towns as well as economic facts for principal countries and geographical and historical facts about the United States.

GUIDES TO THE LITERATURE

The chemical literature is well organized and neatly compartmentalized by types of publications. Guides to the literature will help students to determine where to search for specific information.

Dyson, G. Malcolm, "A Short Guide to Chemical Literature," Longmans, Green and Co., New York, **1951**, $2.

This, the latest and most compact guide, briefly lists dictionaries, encyclopedias, journals, abstracts, and texts. One chapter gives an example of an organic chemistry literature search.

Soule, B. A., "Library Guide for the Chemist," McGraw-Hill Book Co., Inc., New York, **1938**, $3.75.

This is not as up to date, although more comprehensive. It covers the literature by field of chemistry, and contains chapters on the use of the library, patents, government publications, and reports.

Mellon, M. G., "Chemical Publications, Their Nature and Use," 2nd ed., McGraw-Hill Book Co., Inc., New York, **1940**, $3.75.

This book, as well as Soule, is a text, Mellon's being intended for a course in chemical literature taught by the author at Purdue University. It includes sections on patents and other government publications, textbooks and general reference works, and a list of periodical articles for further reference.

Huntress, E. H., "Brief Introduction to the Use of Beilstein's Handbuch der organischen Chemie," 2nd ed., John Wiley & Sons, Inc., New York, **1938**, $1.75.

Beilstein is not only the most important reference work in organic chemistry but also one of the most difficult to use. This valuable pamphlet gives a good description of Beilstein's classification scheme, and illustrates how to find a particular compound.

CUMULATIVE INDEXES

Cumulative indexes are guides to the contents of a number of volumes of periodicals. They are a time-saver in literature searching since instead of having to check up to 46 individual annual indexes, one finds the identical information in just one volume. Some cumulative indexes can be purchased separately, and make an excellent bibliography on certain topics.

Annual Review of Biochemistry, Cumulative Index **1–10**, 1932–41; **11–20**, 1942–51, $6 each.

Annual Reports on the Progress of Chemistry (Chemical Society, London), Cumulative Index **1–46**, 1904–49, $3.50.

Journal of Chemical Education, Cumulative Index **1–25**, 1924–48, $3.

BIBLIOGRAPHIC AIDS

"List of Periodicals Abstracted by Chemical Abstracts," *Chemical Abstracts*, Columbus, Ohio, **1951**, $3.

This book, issued with the 1951 *Chemical Abstracts* Subject Index or sold separately, gives the official abbreviations for periodicals for use in bibliographic citations, a list of libraries receiving a given periodical, its frequency of appearance, and the 1951 volume number.

REPORT WRITING

Hints as to format, presentation, style, and content of a technical report will be found in the following works especially prepared for students.

"What to Think About in Report and Letter Writing," Sun Oil Co., Philadelphia, **1951**, free.

This is a 33-page pamphlet describing the various types of reports, giving guidance in their preparation, and a few notes on grammar.

Kerekes, F., and R. Winfrey, "Report Preparation," 2nd ed., Iowa State College Press, Ames, Iowa, **1951**, $6.80.

This is a more comprehensive text, dealing fully with the collection of information, mechanics of style, and format and arrangements of technical letters, papers, and articles. Each section is illustrated with a reproduction of an original report. The book contains an excellent discussion of tabular presentation and the preparation of illustrations.

Once the student has these basic reference works as part of his own collection and makes efficient use of the information contained therein, the tendency to memorize all data, often carried over from the earliest stages of his training, will be decreased. Independent use of these aids will help to awaken his initiative in finding information for himself. Thus, to encourage him to build up his own reference collection and use it as an everyday tool will help to make him utilize intelligently the recorded literature upon which, in the final analysis, his work is dependent.

ROBERT SCHWARZ

RALPH E. OESPER
University of Cincinnati, Cincinnati, Ohio

EVERY inorganic chemist is familiar with the work of (Karl Gottfried) Robert Schwarz, whose long list of publications has made his name a familiar one on both sides of the Atlantic. He was born in Berlin on December 17, 1887, and studied chemistry at Berlin, Breslau, and Freiburg, where he took his Ph.D. in 1910. His dissertation dealt with "Bohnerztone und afrikanische Erden" and was prepared under the guidance of Wilhelm Meigen (1873–1934) who was much interested in the geological and crystallographic facets of chemistry.[1] The choice of this topic was in line with Schwarz's intention to devote himself, after graduation, to ceramics. For this reason, he worked at first in the Experimental Station of the Staatliche Porzellanmanufaktur in Berlin, but at the urging of his former teacher Ludwig Gattermann[2] he returned to Freiburg to prepare himself for a teaching career. He qualified as Privatdozent at Freiburg shortly before the opening of World War II; his habilitation work dealt with silicon chemistry and was the first of a long series of researches revolving around this element. In 1922 he was called to the chair of inorganic and analytical chemistry at Freiburg; in 1928 he went to Frankfurt as full professor; in 1934 he moved to Königsberg. Since 1948 he has been at his present post, professor of inorganic and electrochemistry at the Technische Hochschule in Aachen.

His youthful choice of silicon as a field of research has been pursued faithfully and in various directions. At first, he studied the chemical processes involved in weathering and kaolinization, and this extended series of researches culminated in 1933 with the successful artificial conversion of feldspar into kaolin. The laboratory synthesis of kaolin led to important conclusions regarding the conditions obtaining in the natural formation of this material. Later, silicic acids were the subject of another extensive series of studies. It was found, contrary to previous assumptions, that this system is not one which can be definitely represented by the general formula $(SiO_2)_x.aq$. Instead, there are definite polyacids, of which the disilicic acids $(H_2Si_2O_5)_x$ can be obtained in crystalline form. Other researches in the field of silicate chemistry include studies of the constitution of porcelain; the electrical conductivity of crystalline and vitreous silicates; the processes occurring during the electrolysis of glass at high temperatures. An entirely different phase of silicon chemistry is represented by his studies of the easily decomposable and air-sensitive compounds containing silicon chains. In 1937 he prepared a compound, $Si_{10}Cl_{22}$, in which ten silicon atoms are directly linked together. Several years later, a compound with no less than 25 links was prepared by this same procedure, namely by thermal treatment of silicon tetrachloride in the quenching tube. When cracked, such long-chain compounds go over into a highly polymeric monochloride, $(SiCl)_x$, and ring-shaped silicon chlorides can be obtained as intermediate products. The first member of this new class is $Si_{10}Cl_{18}$, which has the structure of a perchlorsilicodecaline. Recently he has devoted considerable attention to silicic esters, and has prepared, for the first time, a large number of these compounds.

Since germanium is so closely related to silicon it was but natural that it too became the subject of many studies. Among the important feats in this field were the preparation of an optically active germanium compound; polygermene $(GeH_2)_x$; germanium-nitrogen compounds; heteropoly acids; and numerous organic germanium compounds.

Other studies in the inorganic field of special interest dealt with: the peroxides of titanium, zirconium, hafnium, and thorium; peroxy nitric acid; the constitution of chromium peroxide CrO_5 and the blue perchromates; sulfur tetroxide; the bromine oxides BrO_2 and Br_2O. The preparation of these oxides was accomplished by the reaction of the components in the glow discharge, which thus showed itself to be a real aid in the field of inorganic preparative chemistry.

Studies of medico-chemical character yielded especially a new colloid-chemical spinal-fluid reaction in which he employed "siliquid," (a colloidal dispersion of SiO_2), and gave new insights into the processes of bone formation.

Other researches in the non-inorganic field have dealt with the pyrogenic syntheses of hydrocarbons in the quenching tube. Papers of a more theoretical nature discussed the relation of silicon and carbon chemistry, and the polarity principle in chemistry. A full view of the breadth and depth of his interests can only be gained by an examination of the titles of his papers (about 175) in the indexes of *Chemical Abstracts*.

Among his books, the best known are: "Chemie der anorganischen Komplexverbindungen," which was translated into French, Spanish, and English (New York, 1923); "Anorganische Chemie"; "Chemisches Praktikum für Mediziner." A very successful teacher, he has trained a large number of competent chemists.

Professor Schwarz is a Corresponding Member of the Deutsche Akademie der Naturforscher and holds the Alfred Stock Memorial Prize.

[1] For biographical details of Meigen, see WEITZ, E., *Ber.*, **68 A**, 29 (1935).

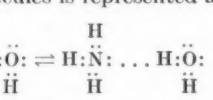
[2] See OESPER, R. E., J. CHEM. EDUC., **19**, 444 (1942); SCHWARZ, R., *Chem. Ztg.* **44**, 513 (1920).

AMMONIA AND "AMMONIUM HYDROXIDE"

JOHN B. DAVIS
American International College, Springfield, Massachusetts

A NUMBER of years have elapsed since there has been any significant change in the formulation and the teaching of the basic concepts of chemistry. Moreover, what seems to be more serious, several of the textbooks that have passed through this laboratory during the past year seem to represent a tendency on the part of some textbook authors to revert to ancient and worn-out expedients which have long since outlived their usefulness. Many new data have been obtained from many sources, and these new facts demand a decided revision of (1) certain chemical theories, and (2) equations representing certain reactions.

One of the several reactions that needs reevaluation in the light of the modern theory of valence is the reaction between ammonia and water. Ammonia is commonly represented as reacting with water to form ammonium hydroxide, NH_4OH. Now if a molecule is defined as a group of atoms held together by covalent bonds, it is immediately obvious that no such molecule as that represented by the formula, NH_4OH, actually exists. The water molecule and the ammonia molecule are indeed attracted to each other, and this attraction is the result of the so-called hydrogen bond. The name, hydrogen bond, is misleading, since the force acting between the two molecules is not of the nature of a true chemical bond but can be described more accurately as a dipole-dipole attraction. It appears that when the hydrogen atom is bonded to a small, electronegative atom, the strong pull which the atom exerts on the bonding electrons leaves an effective positive charge on the hydrogen atom which is sufficient, because of the absence of shielding electrons, to cause attraction for a second electronegative atom.[1] Hence the hydrogen atom bonded to the electronegative oxygen atom of the water molecule will attract the electronegative nitrogen atom of the ammonia molecule. Using a dotted line to represent the dipole-dipole, the combination of the two molecules is represented as follows:

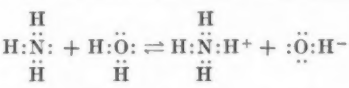


This bond is longer than the normal covalent bond and this fact seems to preclude the possibility of resonance.

The hydrogen bond is comparatively weak, having roughly 5 per cent the energy of a covalent bond. It follows that the energy of activation of such a bond is small and, consequently, the bond forms and breaks with ease at ordinary temperatures.

In a 0.1 molar solution of ammonia in water, the water molecules outnumber the ammonia molecules 550 to 1; and this would appear to be an ideal environment for the practically complete reaction of ammonia with water if any valence bonds of significant strength existed between these molecules. This reaction is far from complete, however, and, according to Sidgwick,[2] about 46 per cent of the ammonia remains free and unhydrated in such a solution. This unfavorable equilibrium shows beyond a doubt that the force of attraction between these two molecules is very weak, and the combination of these two molecules is unstable and tenuous. The well-known fact that ammonium hydroxide cannot be isolated by carefully evaporating an aqueous solution is further proof for this conclusion.

If any additional clarity were gained by the use of the fiction of the ammonium hydroxide molecule, perhaps its continued use might be justified. But this is not the case. The teacher can present the chemistry of ammonia more clearly, and at the same time find himself in a much sounder position from the point of view of the theory of chemical valence, by simply representing the reaction between water and ammonia thus:



and the equilibrium constant for the reaction by the following equation:

$$K = \frac{[NH_4^+]\ [OH^-]}{[NH_3]}$$

To summarize:

(1) There is no true chemical bond acting between ammonia molecules and water molecules.

(2) These molecules are attracted to each other by a dipole-dipole force which is roughly 5 per cent of the strength of a covalent bond.

(3) Even under favorable conditions only about half of the ammonia molecules are hydrated in aqueous solution.

(4) The force between the water molecules and the ammonia molecules is so weak that the hydrate cannot be isolated by the most careful evaporation of the aqueous solution.

(5) Nothing is gained in clarity or understanding by continuing the fiction of the reality of the ammonium hydroxide molecule.

[1] MOELLER, T., "Inorganic Chemistry," John Wiley & Sons, Inc., New York, 1952, p. 189.

[2] SIDGWICK, N. V., "Chemical Elements and Their Compounds," Oxford University Press, London, 1950, Vol. 1, 658–60.

THE OPERATION OF A MULTIPLE STOCKROOM[1]

ALBERT H. HOLTZINGER
The Pennsylvania State College, State College, Pennsylvania

THE basis of this article is the multiple stockroom set-up used by the Chemistry Department at The Pennsylvania State College. At present, we are operating one reserve stockroom and four retail storerooms. Although we are just moving into our new reserve stockrooms, the reserve stockroom is not a new development at The Pennsylvania State College, since we have been operating from a reserve stock for a number of years. Fortunately it became possible to design and build modern stockroom facilities when our present building program was activated. These facilities will be used jointly by the Department of Chemistry and the Petroleum Refining Laboratory which is a separate division of the School of Chemistry and Physics.

The storage area is not part of the main campus. There are two important reasons for this: safety and construction cost. The hazards involved in the storage of chemicals are well known. As a matter of fact, in some instances, particularly in the case of the more volatile flammable solvents, it is necessary to balance storage problems against the price advantage of quantity buying. The second factor, construction cost, was very important to us. We could not use cinder block construction on the main campus. The choice was between a much smaller higher-priced storage area and the present expanse of relatively low-priced storage.

Each of the two buildings consists of four separate units, 30 feet wide and 60 feet long, each of which is accessible to trucks from both the front and the rear. The large sliding doors provide an opening 10 feet wide and 10 feet high, thus permitting deliveries to be made inside the various units. No loading platforms are provided, since we believe it is more economical and convenient to use a mechanical loader. One of the buildings (B) is designed for flammable storage. Each of its four units is protected with a fog system actuated by a rate-of-rise head. This latter is a device which is unaffected by ordinary changes in temperature, but is set off by a rapid rise in temperature. All fog nozzles in any given unit operate at the same time. In the event of fire, there will be a fog blanket throughout the unit to prevent re-ignition of vapors and to cool all other volatile materials as rapidly as possible. The other building (A) is designed for storage of inorganic chemicals, laboratory apparatus, glassware, and the like. The unit at the one end of this building is subdivided to provide office space and toilet facilities. An ordinary sprinkler system is used for fire protection. This means that in case of fire, only the sprinkler heads in the immediate vicinity of the fire will go into operation. However, rate-of-rise monitors are also used in these units to permit water to fill the mains prior to the melting of a sprinkler head. The rate-of-rise monitors in this building do not actuate the sprinkler system; their sole function is to set off the alarm and permit water to enter the mains. Unless a sprinkler head fuses, no water is sprayed into the unit. However, the operation of the sprinkler system does not depend upon prior operation of the rate-of-rise monitor. If a sprinkler head is fused, the alarm is set off, water enters the mains and is discharged from the open sprinkler. As is evident from the above description, dry systems are used for fire protection. While this entails a slight delay in the operation of the sprinkler and fog nozzles, failure of the system from frozen lines is prevented.

The buildings were designed to provide a safe storage area. Each unit in a building is sealed off from the neighboring units with a concrete block wall. All switches and electrical fixtures are of either vapor-proof or explosion-proof type. There are no electrical outlet receptacles inside the flammable storage area. Each of the eight units has an emergency shower. Each unit has two exits, in the form of pilot doors, one at either end.

There are two offices in the front third of Unit I in Building A; one of these offices will be used by the Petroleum Refining Laboratory and the other one by the Chemistry Department. Between the two offices is sufficient space to house the mechanical loader and other common equipment. The valve room for the sprinkler system and the toilet room are also in this unit. Steel shelving is provided in the other two-thirds of this unit for inorganic chemical storage. Unit 2 is mechanical storage for the Petroleum Refining Laboratory. No shelving is provided in this area. Unit 3 is Pyrex storage. Shelving and bins are provided along one wall for the storage of glass tubing and rods, and smaller laboratory supply items such as watch glasses, sponges, iron rings, porcelain ware, corks, rubber stoppers, and the like. The major portion of this area is used for case lots of glassware. Unit 4 is acid storage. The bromine and sodium room is in the one corner. This room is completely separated from the main acid storage and, needless to say, it is not sprinkler protected. Heavy

[1] Presented as part of the Symposium on Storeroom Management, etc., at the 122nd Meeting of the American Chemical Society, Atlantic City, New Jersey, September, 1952.

wooden shelving was installed in this room, since less than case lots may be stored in this location. No shelving is provided in the main acid room since nothing but full or empty cases will be handled in this area.

Units 5, 6, 7, and 8 are in Building B, under fog protection. Unit 5 is organic chemical storage. Steel shelving is used throughout this unit which will house the finer organic chemical supply, as well as compounds prepared in thesis work. A portion of this area also may be used to store some smaller miscellaneous supply items. Unit 6 is bulk solvent storage. Both barrel racks and steel shelving are used. I-beams were installed above the barrel rack aisles to permit use of traveling chain hoists for handling barrels. Compressed air is available in this unit to facilitate thorough airing of the barrels before return to the shipper. Units 7 and 8 have been assigned to the Petroleum Refining Laboratories. Unit 7 is a Barrel Room, and again I-beams for chain hoists have been provided. Unit 8 contains steel shelving and is used for organic storage.

OPERATION OF RESERVE STOCKROOM

No broken case lots of laboratory supplies are held in the reserve stock, with the exception of a few items which normally are not purchased in case lots, such as ring stands, trip balances, clamps and clamp fasteners. If a retail store needs supplies, a full case is withdrawn from stock and if necessary, the case is divided among the several storerooms. In the matter of chemicals, no broken bottle lots are held in reserve. Although an attempt is made to purchase in standard case lots to obtain the price advantages, the retail store is supplied in single bottle quantities. The size bottle purchased is dependent on the chemical and its use. As a general rule the largest size that is consistent with good practice is stocked. In some cases different sized bottles of the same chemical are used. If a pound of a particular reagent will last a laboratory for a year, obviously this reagent should not be purchased in five-pound bottles; on the other hand, if the laboratory uses ten pounds of a chemical per week, normally this material should not be purchased in one-pound bottles. The common acids and ammonium hydroxide are dispensed from reserve stock in case lots. Two sizes are used, the regular five-pint bottles and the one-pound bottles. Acid is not purchased in carboys despite the fact that acid is bought in car load quantities. It is believed that it is worth the higher price to avoid the transfer to smaller bottles with its attendant labor cost and safety hazards. Solvents and some of the more common organic liquids, with the exception of ethanol, are dispensed from the reserve stock in five gallon containers.

There is no justification for the operation of a reserve stockroom unless purchases are made in quantities that will provide maximum possible discount. For instance, it is foolish to buy ten cases of Pyrex per month—it is much cheaper to buy 120 cases of Pyrex once a year. The same thing is true in the case of all other quantity discount items; purchases must be grouped for maximum saving. Normally a reserve stock should be built up carefully and gradually. It is necessary to maintain an accurate and up-to-date perpetual inventory of the reserve stock, since this alone can give a real picture of present and future demands on the stockroom. It must be remembered that staff members rely on the reserve stock for their supplies, and unless there is sufficient supply on hand to meet anticipated needs, difficulties may arise. In the case of the undergraduate laboratories, it is rather easy to predict the requirements a year in advance unless the undergraduate program is in a state of flux and the staff members in charge don't know what they are going to need, and under those circumstances one just hopes for the best. In the case of the graduate and research laboratories, the problem is more difficult. It is practically impossible to predict the special needs of these groups, although certain standard items frequently are used in almost fixed quantities. So despite the fact that it is generally advantageous for most schools to make one major purchase each year, it always will be necessary to make some interim purchases.

An outline of the system used in setting up the annual order at The Pennsylvania State College may be of interest. Early in the second semester the head stockman checks his running inventory of the reserve stock and makes certain that his records are up to date. At about the same time, a note is sent to each senior staff member requesting a list of special items needed for the next academic year. The notice specifies that chemicals and equipment ordinarily used in the undergraduate courses will be ordered as a matter of routine. However it is the responsibility of the staff member to give notice of any proposed changes in the course that may affect chemical or equipment needs, for it is just as important to know what not to buy as it is to know what to buy. The deadline set for the replies is usually about three weeks prior to the deadline for completion of the order.

Next, the inventory cards are reviewed to compare the reserve stock with the amount used during the current year. If the amount on hand is not at least twice the amount used during the year, that item is placed on the tentative order list. If the amount used during the year differs very much from the average usage over the past several years, the reason for this difference must be found, and the amount placed on order must be adjusted in the light of this information. The last step in preparing the tentative order is the final checking of the staff members' requests against the inventory cards and the order list. The tentative order then goes to the Purchasing Department, where it is combined with orders from other departments or schools of the college. This combined list is sent to various supply houses for competitive bidding.

THE RETAIL STOREROOMS

As mentioned previously, there are four retail storerooms in operation. No attempt is made to carry a complete line in any one of them. Each one is stocked to meet the normal demands of the group served by that

particular storeroom. It is the responsibility of the storeroom man to maintain an adequate stock to serve his laboratories.

Except for three things, no attempt is made to inventory the retail storerooms. The exceptions are ethanol, narcotics, and platinum ware. Special procedures have been established for handling these items.

There are no cash transactions at any of the storerooms. However, three other types of purchases can be made, and these will be discussed in conjunction with the services to which they apply.

The service to the undergraduate laboratories operates very smoothly. In most of the laboratories, the student is assigned to a specific working space and an individually locked drawer or cupboard. In the undergraduate organic laboratory for instance, there are four cabinets or drawers at each working space. Each drawer is permanently stocked with the equipment needed for the courses given in that laboratory. Through the cooperation of the staff members involved it was possible to standardize on a list of apparatus which is suitable for any one of the five different courses given in this laboratory.

At the time of his first laboratory class, the student is given the key to his desk and an equipment list. The student checks the equipment in the desk and any shortages due to missing or broken items are corrected during this check-in period. The equipment then becomes the responsibility of the student. At the last meeting of the laboratory section, the student is checked out by his laboratory instructor. The equipment in the desk must be in first-class condition and must correspond with the original check list. All shortages must be made up by replacement from the stockroom. It is to be noted that this equipment is kept in the desk and is not returned to the stockroom.

Purchases by the undergraduate are made with a breakage ticket similar to the ordinary meal ticket. The student buys this ticket from the college Bursar at the beginning of the semester. The ticket must be presented at the storeroom before a key to the desk can be obtained. At the same time the key is issued, the ticket is punched in the upper right hand corner. This punch serves several purposes. It prevents more than one student using the same ticket to obtain keys to two or more laboratory desks. A ticket which has not been punched can be certified for full refund at face value simply by presenting it to the office of the Director of the Chemical Laboratories. However, if there is a punch in the upper right hand corner, the ticket will not be certified for refund unless it bears an authorized signature indicating that the desk has been checked and found in order. At any time during the semester the student may make purchases from the storeroom by presenting his ticket. The amount of the purchase is punched from the ticket. At the end of the semester, after the desk has been checked, any unexpended portion of the breakage ticket is certified for immediate cash refund by the Bursar. Incidentally, the student cannot obtain a refund on any apparatus purchased from the storeroom.

There is an interesting sidelight on these refunds. The student counts the amount due him, and these figures are checked twice—first by the laboratory assistant and then by the certifying officer. As might be expected, quite a few errors are discovered, but almost invariably the errors are in favor of the college and not the student; the ratio seems to be about 100 to 1.

At the present time, in all but the freshman laboratories, solutions and side shelf reagents are the responsibility of the staff member in charge of the laboratory. Frequently graduate students are used in this laboratory preparation service. The needed chemicals are drawn from the retail storeroom for the particular course involved. Sometimes chemicals are purchased specifically for a particular course. If the chemicals have not been delivered to the staff member in charge, they may be stored either in a retail storeroom or in the reserve stock. In either case the chemicals are marked for that specific use, and cannot be obtained for any other purpose except upon written authorization from the Director of the Laboratories or the staff member for whom the material was purchased.

In the freshman laboratories, the chemical supply problem is handled in a different manner. Most of the chemicals needed are supplied in kits, which must be purchased by the student at the beginning of the semester. The kits contain the dry chemicals that will be used by the student during the first two semesters of college chemistry. Similar kits are used by the quantitative group. The merits of the kit system for supplying chemicals will not be discussed at this time, other than to state that they are very convenient from the point of view of laboratory service. Of course there are still the usual side shelf and desk reagents to be handled. A full-time laboratory preparation man provides this service and performs certain other related duties.

Servicing the graduate laboratories is a different proposition. Permanently stocked desks and breakage tickets are not used. When a graduate student has been assigned working space he opens an account at the nearest storeroom. He draws from the storeroom the laboratory supplies and ordinary chemicals he needs. This represents the second type of purchases. The student signs for his purchases at the storeroom on two five- by eight-inch cards. One card is used for returnable items such as iron and glassware; the second card is used for expendable items such as rubber or glass tubing and chemicals. At the end of each semester the graduate student checks out of, and back into, the laboratory. Normally this is a rather informal process. Using his returnable item card as the basis, the student indicates the equipment he still needs by listing these items on a new card. Materials no longer needed are cleaned and returned to the storeroom. Equipment which has been lost or broken is listed on the expendable item card which is priced and sent to the office of the Director of the Chemical Laboratories.

There is only informal control over the purchases of the graduate students. The retail store clerks are experienced men and are quick to recognize unusual withdrawals of chemicals or materials. Such cases are called to the attention of the Director of the Chemical Laboratories for it is not the prerogative of the stock clerk to officially question the needs of a research worker. If it is felt that the withdrawals are excessive, the senior staff member in charge of the research is consulted and then either the stock clerk is notified that the withdrawals are in order, or the graduate student is requested by the senior staff to account for the excessive withdrawals. Unusual chemicals are ordered on request of the research director with the approval of the Head of the Department. More complicated and specially designed glass apparatus may be obtained from the department glass blower upon request of the director of the student's research. Such glass blowing orders pass through the office of the Director of the Chemical Laboratories.

The present method of handling capital equipment items is not entirely satisfactory. However, a classification system has been devised that will at least partially solve many of the problems. Four categories will be used. First there is the equipment which is an integral part of a laboratory and can be used only by members of that laboratory group. A helium compressor in the cryogenic laboratory would be an example. In the second category are those pieces of equipment which are assigned to a laboratory and which can be used in that location by other workers with the consent of the senior staff member in charge of that particular laboratory. A constant temperature bath or a spectrophotometer would be in this class. The third category will include equipment that could be borrowed and used in a different location with the consent of the staff member responsible for the apparatus. Some of the equipment used in the undergraduate physical chemistry laboratories would be in this class. The fourth category will include the more common equipment items that can be used on short term loans. Vacuum pumps and pH meters would be in this class. This equipment will be handled from a special research storeroom. At present, this fourth category is part of the previous one, because there was no available space to operate such a storeroom. This has resulted in inefficient use of some of this equipment, partly from lack of proper control and partly from lack of knowledge of what is available.

Storeroom accounts of staff members doing individual research work are handled in approximately the same manner as that described for the graduate student.

The storerooms frequently serve other departments in the college. This represents the third type of purchase, and such purchases are made with regular college requisitions, issued by the college purchasing agent.

A reciprocal loan service with some of the other departments also is operated. This is an emergency service used when the amount of materials on hand is too small to permit permanent withdrawal by another department. The items are released on a loan slip with the understanding that they will be replaced as soon as possible by the borrowing department.

CONCLUSION

One of the most important factors in successful operation is proper bookkeeping. Records must be accurate and up to date, otherwise service will die from insufficient stock or will bog down in excess dead stock. On the other hand, it is possible to record-keep a reserve stockroom right out of business. In the Department of Chemistry at The Pennsylvania State College, efforts have been made to reduce the paper work to a minimum. No undergraduate accounts are kept. A perpetual inventory of the reserve stock is maintained. Although practically every item in stock is eventually charged against an individual or a course, once an item is removed from the reserve stock, the item is no longer an inventory item. The retail storerooms are not charged formally with these items, nor are they required to account for them. No cash transactions are used, and therefore no cash accounts must be kept. Over-all the system described is simple, efficient, and economical.

REQUIREMENTS AND RESPONSIBILITIES OF A TECHNICAL EDITOR[1]

FLORENCE E. WALL
New York, New York

RESEARCH laboratories and management in industry are becoming increasingly aware of the need for someone skilled in technical writing and editorial work to ensure that reports and papers for publication are in correct form.

In times of war and stress all branches of science speak for themselves. The necessary lack of publicity on scientific research and progress during war is negative, but just talking about this lack is still publicity. Come peace again, the scientists all retire into their holes and ivory towers and the fog of mystery again engulfs them. If the public is to be encouraged to give both financial and moral support to scientific research, surely this can come only through better public understanding of what scientists in general—and for us, chemists in particular—are doing to merit it.

A search of the literature has revealed pitifully little on technical editorial work. Forty years of *Chemical Abstracts* showed only two references (*9, 13*), both traced to the "Symposium on Nonlaboratory Jobs for Chemists" on the program of the Division of Chemical Education at Cleveland in 1944. In the voluminous files of the New York Public Library, "technical journalism" was specifically mentioned in the titles of one article (*15*) and one book (*1*); considerable useful information can be found in an occasional chapter or section throughout other books and articles on journalism (*5, 7, 11, 14, 24*). As there is necessarily much overlapping of the subjects of technical literature and technical writing in general, several of the well-known textbooks give varying amounts of information on editing. On the whole, however, it seems clear that whatever most technical editors have learned they have had to assemble for themselves, picking it up by a kind of apprenticeship and by analogy—both for the Do's and for the Don't's—to practices in general journalism, if they know how to recognize it and adapt it (*5, 6, 7, 10, 23, 26*).

The first college course in scientific reporting and editing was introduced at the School of Commerce of New York University in 1945, in cooperation with the National Science Writers Association, and is still being offered (1953). Other courses of similar content will undoubtedly be offered elsewhere as the demand for them rises.

There has been an enormous amount of criticism of the lack of adequate expression for chemistry—both on what the chemists are doing and on the means of promulgating information about it to the public.[2] This does not imply any deficiency on the part of that small but gallant band of official writers on science in our daily press. They seem to be indefatigable and they have done themselves proud, but even their work would be made much easier if all those behind the work in laboratories were more articulate in peace time.

The poor English of both chemists and engineers has long been the subject of criticism. Those outside the professions both condemn and ridicule the scientific "gobbledygook" that pervades many publications on science. The deficiency is admittedly due to lack of balance in the educational preparation for these professions. Training both for chemistry and for various branches of engineering has been confined almost exclusively to subject matter, the idea being, evidently, that if a man really knows what he has been doing and has a strong enough urge to tell others about it, he will be competent to do so. The mere desire to write does not induce any spontaneous generation of skill, and the results would often be laughable if they were not so pathetic, simply because so many professional and technical men do not know how to use their own language correctly and effectively. Through the efforts of the A. S. E. E. (*16, 20*) the engineers have been actively doing something about this. As long, however, as nothing is done officially to ensure adequate, uniform training in good English for chemists—preferably on the undergraduate level—there will always be a need for skilled technical editors.

FUNCTION OF THE EDITOR

According to some definitions submitted by a class of boys,

> An editor makes his living out of the English language.
> An editor is someone who does not do anything himself, and when somebody else does, he goes and tells other people about it.

Webster's dictionary defines an editor as

> Someone who prepares copy for publication.

This kind of preparation is usually understood to mean marking copy with indications for size and style of type, spacing, and other directions for the printer. Strictly interpreted, the duties of an editor comprise the correcting of errors and general improvement in the

[1] Presented at the 112th Meeting of the American Chemical Society, New York, September, 1947.

[2] *Public* means here anyone and everyone outside of the laboratories proper—directors and management of companies, investment brokers, and others—because so many of these are nontechnical men.

appearance of a book or article, but not rewriting; in other words, the function of an editor is critical, not creative. However, until all offerings submitted to editors are vastly better than they are now—until, in fact, they are so well organized and composed that only mechanical details must be supplied—many editors will have to do a certain amount of rewriting for effective presentation of material.

A "technical editor" is usually understood to be a person charged with preparing for publication any material that deals with science and technology.[3]

Many so-called technical editors criticize copy only for content. If the information is correct they are indifferent to the manner in which it is expressed. "Our readers will understand" is no reason for passing slovenly writing; it is, in fact, an insult to the intelligence of those readers.

Technical editing calls for a combination of abilities, based on knowledge of both the technical aspects of the given subject and the mechanics of correct writing—not necessarily on a flair for writing for its own sake. The difference between technical writing and technical editing can be well explained in this way: In good technical writing all details should be so clear that, as if he were looking through non-reflecting glass, the reader is not conscious of the medium; the technical editor, then, is the artisan that helps to make the medium of expression invisible.

OPPORTUNITIES

An eager applicant for information and advice once remarked, a bit ruefully, "But there are only ten or a dozen scientific and professional magazines, and their editors are set for life! What chance does a fellow have?"

Fortunately for everybody, the vocational opportunities for a technical editor with chemical background are not limited to the position of editor-in-chief of the relatively few scientific and professional papers. A practicing technical editor may be a co-editor or associate editor on the staff of any periodical—the person responsible for the correctness of the information that the paper is to publish on science and technology. In laboratories, the editor is usually responsible for the good form and effective presentation of the reports on work that is in progress and other publications of the staff.

Whether or not they are so designated, Kirkpatrick reminds us, technical editors may and should be found on the staff of news services, newspapers, and magazines directed toward various industries and trades; on house organs of companies in those same industries and trades; with publishers and printers of technical and scientific books (very badly needed!); advertising agencies, public relations bureaus, testing bureaus, consumer service bureaus, several branches of government service; and in consulting work as critic, coach, and ghost writer (*9*).

In laboratories particularly, where proper expression is so important, the type of work implied in the occupation of technical editor should not be left to an overworked director, project leader, or section leader; to a librarian simply because he or she knows something about books, searching, and abstracting; or to just anyone that can give some time to it. It should not be assigned to anyone that has not made a study of the obligations of such a position.

Writing about chemistry, either creative writing by the individual or editing the writing of others, should appeal to those that are euphemistically called "mature" (by present criterion, seemingly, anyone over 35), and employers with such positions to offer should welcome older applicants. Years of experience, besides furnishing the diversified background in laboratory or industry, and a broader knowledge of a given branch of science and technology, should also have engendered in the individual the greater sense of moral responsibility and the tolerance and judgment required.

PROFESSIONAL BACKGROUND

In addition to the general and special knowledge of his field of operation, any would-be technical editor should have a good understanding of news values, and of business psychology. The following points are of most importance to us here:

Science

The scientific background of the technical editor should be as broad as possible. Even in a position that seems to be narrowly confined to one branch of science or industry, the editor should have a fair acquaintance with other branches of science and other industries and trades that border on his own. This is especially necessary in the matter of reference literature, in order to supply the kind of information that one may not have but which one can find. Familiarity with all the standard works of reference in chemistry and a wide variety of professional and trade publications is essential.

Language

In the trained technical editor good English should be taken for granted. If it is essential that certain common errors be caught and corrected in non-technical journalism, how much more important these same errors (and many more) are in writings about science! The technical editor should be skilled in all forms of composition: *narration*, for correct historical sequence; *description*, for proper balance in details; *exposition*, for clear explanation of ideas and procedures; and *argumentation*, for the making of good outlines and briefs.

As to style, language can be considered of four types: *literary*, *commercial*, *colloquial*, and *slang*. General journalism tends more toward the English of business

[3] Unpublished free-lance definitions overheard from time to time have characterized a technical editor in choice four- (or five-) letter words, such as "stab in the back," "thorn in the side," "pain in the neck." Long intimate study of the animal seems to reveal an odd biological specimen—an anthropoid hybrid with strains of bull-dog, ferret, and goat, with the neck of a giraffe, and the hide of an elephant.

with leanings toward the literary, and technical journalism should do the same. This is logical because if scientific English is—or should be—the most exact form anyone can use, then business English, by the very nature of the demands made upon it, should be next. Colloquial language, especially the jargon of the trades, and slang, should be avoided.

Even more than other editors, a technical editor must be concerned with what an author is trying to say as well as how he is trying to say it. Despite what so-called "progressive education" has done to the study of grammar and spelling, those that intend—or are otherwise compelled—to do any technical writing simply have to know the good old rules of grammar, the relationship of parts of speech in a sentence, the shades of difference in the meanings of synonyms, and other fine points which often make all the difference between cryptic technical jargon and lucid scientific exposition.

Mechanics

(*1*) *Technical Editor's Tools.* Among the useful tools of his craft, every technical editor should have at hand at least one of the comprehensive guides to the literature of chemistry: those of Crane and Patterson (*4*), Mellon (*12*), and Soule (*17*). To refer you to these guides saves the repetition of long annotated lists of publications.

Some favorite books always within my reach are:

Webster's Collegiate Dictionary
Chicago Manual of Style (*11*)
Hotchkiss and Drew: Business English
Eidesheim: Editor at Work (*6*)
Rickard: Technical Writing (*16*)
Perrin: Writer's Guide (*14*)
Merck's Index
World Almanac

Other books frequently consulted, which might well be accessible and useful, are:

A good encyclopedia (Brit. XIII suggested)
A good handbook on secretarial practice (Hutchinson, McGraw-Hill, suggested)
Encyclopedia of Chemical Technology
Fishbein: Medical Writing
Fowler: Modern English Usage
Muret-Sanders Dictionary (for German)
Nuovissimo Melzi (for Italian)
Pequeño Larousse Illustrado (for Spanish)
Petit Larousse Illustré (for French)
Callaham or Perry (for Russian)
Thomas' Register of Trademarked Products
U. S. Government Manual
U. S. Pharmacopeia
Webster's Unabridged Dictionary

For certain trades and industries,

Moody (or Poor) on Public Utilities, Railroads, Industries

For checking names, titles, and qualifications of individuals,

American Men of Science
Who's Who in America
Who's Who in Commerce and Industry or Chemical Who's Who

(*2*) *Condensing of Copy.* The first task on any piece of copy is to give it a routine reading and decide whether (usually, rather, *how much*) it should be condensed. It is extremely rare for any editor to have to ask any author to "unboil his stuff"; as a rule he must condense whatever is submitted. This operation is valuable in any publication, but in contributions for contemporary scientific periodicals, because space in them is at a premium, it is absolutely essential.

Even after an unusual author has tried to condense his own composition, the editor may be able to prune it still further. Three methods are recognized (*7*):

Trimming, which means a general tightening of the copy effected by eliminating all superfluous words without sacrifice of information (method of *Reader's Digest*).

Cutting, which eliminates all but the most important facts.

Boiling, which shortens all sentences and sacrifices minor facts. In this technique one well-chosen adjective may be substituted for a rambling clause.

In any method of condensing copy the editor must guard against any change in the sense of the article, even any change in emphasis or impression. As far as possible all copy should be condensed in the original manuscript; although it is often necessary to make further cuts on proofs, for the sake of pulling up a short line ("killing the widow").

(*3*) *Typography.* Some knowledge of typography should be required of all technical editors, whether their publications are to appear in print or in typewriting. Many editors just stumble along with what they may have managed to pick up from a few style books and the patter of the printers, but real study of the subject is both merited and highly rewarding. For proper appreciation of good typography one must have keen visual imagination, so as to be able to see just how a piece of copy will look in print. Courses in typography, as well as in editing and proofreading, are available in schools of journalism, in many trade schools, through printers' associations, and from consulting typographers. A knowledge of type faces and what to do with them will always be useful.

(*4*) *Style.* Once he understands something about typography, for whatever phase of technical editorial work in which he is engaged, the editor must set his style for the form of his publications and keep to it. Staff, printers, proofreaders, typists, and authors should conform to whatever rules are established for spelling, punctuation, capitalization, numerals, hyphenation, and anything else that may be demanded by the particular needs of the specific publication.

Editors will be spared many hours of work when all authors of papers or reports will take the trouble to study the requirements of publications and plan their writing accordingly. This is especially necessary in the form adopted for citations, bibliographies, and illustrations. Several publications of the A. C. S. and many publishers of technical books and periodicals (*18*, *25*) issue their regulations in printed form. A little study

will show any well-meaning person the form used by others. In laboratories it is not too much trouble to prepare a mimeographed bulletin, giving basic requirements for reports and other written material; and someone should be authorized to make authors follow them.

(*5*) *Illustrations.* Even in establishments where illustrations may be handled by an art editor, they reach the editor eventually for decisions about captions, legends, and display. Where the editor has full responsibility for all phases of production, he must understand the choice of effective detail for proper display; enlarging or reducing the size of an illustration, fitting captions or legends to space, and other details which make the difference between a sloppy job and a professional-looking one.

(*6*) *Layout.* Artistic layout of copy is also important, for most economical use of space. The plan of a "dummy" for paging; correct balance of articles, illustrations, and advertising, if any; the breaks in the text—all these points are the responsibility of an editor, not to be trusted to a compositor who would just chop up long blocks of type and "arrange the stuff somehow." Too many publications show neglect of this kind.

(*7*) *Index and Bibliography.* The correct indexing of long reports, books, and other publications is another skill in art-and-science which may become the responsibility of a technical editor (*22*). It is far better for the author to make his own index, especially for a scientific or technical book, rather than to hand the book over to a professional indexer who is paid a price for each entry. In the latter arrangement, quality is often sacrificed to quantity.

In all citations, bibliographies, and lists of references, the technical editor must make allowances in typographical style according to whether the final publication is to be printed or typewritten. Double and single underlining, which indicate different faces of type to a printer, means double work for a typist. For typewritten reports and other publications the designation of volume and pages can follow uniformly the form used by many for references in *Chemical Abstracts*, *e. g.*, **30:** 694–713 (1946).

In references, the editor must check *everything.* Many errors have been kept out of bibliographies because an editor knew a certain volume could not possibly have been so numbered for a certain year; or recognized that the name of a periodical was wrong.

(*8*) *Proofreading and Reading Proof.* It should seem safe to assume that all good printers have reliable proofreaders for the mechanical checking of proofs against copy, but absolutely nothing can be taken for granted. Proofreading requires training; it should not be delegated to just any pair of girls or boys around an office who happen to have some time on their hands. It seems though, as if this is one sure place where one can find the truth of Alexander Pope's comment in his "Essay on Criticism":

> Whoever thinks a faultless piece to see
> Thinks what ne'er was, nor is, nor e'er shall be.

Despite checking by readers many errors can still slip through and these may or may not be caught by the editor or the author when he *reads the proofs.* It must be emphasized that proofreading is a mechanical process, which critically checks the medium; reading proof is a mental process which checks the copy for sense. The editor is responsible for the last look, and still one more look, both from printer and from typist, and must be a veritable Argus.[4]

PUBLIC RELATIONS

Editors can help both future contributors and themselves if they will insist on copy that is clear, correct, and carefully prepared (*13*, *24*). Every editor of a trade and technical publication, whether or not it pays for contributions, could well prepare at least a single sheet of instructions to prospective contributors. By making clear the field of interest, and all requirements as to form, style and illustrations, such instructions would undoubtedly prevent the rejecting of many manuscripts (or return for major changes), and thus save considerable disappointment and trouble for both sides.

Editors can also bring pressure to bear on the administration of technical schools and colleges to give more instruction in English, with the view to eliminate present errors and gradually improve expression for the technical professions (*13*, *20*, *21*, *24*). It should certainly be easier for a trained chemist to master the principles of good technical writing—as he would any other tool of precision—than it is for even the best of trained writers to acquire a background of science. If professional and technical men would only not have the idea that there is something "sissified" about good speaking and writing, more of them might be willing to study and perfect themselves. For anyone, this can become a beneficial hobby. The more one learns, the more fun it is (though sometimes with chagrin) to review critically one's own earlier efforts with the intention of editing and improving them.

ETHICS

Interesting—fascinating—as this kind of work can be, "fixing up" the writings of others is one of the most thankless of al jobs. One needs much tolerance and patience and understanding to maintain equanimity on many occasions that arise in the daily life of a technical editor. All "editees" are at the mercy of any editor, but every editor is under certain obligations to those whose work he handles, regardless of his private opinion of it (*2*). Some cardinal points are:

(1) Never mention the condition of any author's work, nor the amount of correcting or revising it required.

[4] Last spring I was nicely caught in a slip of this kind, and nearly laughed outright when, while actually reading my paper on Ostwald, I saw that a pencilled interpolation about "Chilean nitrates," on a page of otherwise perfect typing, had been copied as "chicken entreats."

(2) Never make changes in copy, or ask an author to make changes, which the author does not think to be right.

(3) Never make changes in content without consulting the author, or publish changes which have not been referred to the author.

A technical editor is especially obligated to work closely with his authors or some terrible "boners" may result, both in expression and—more serious—in content. To plead extenuating circumstances, such as having to meet a deadline, may seem to be a sufficient reason for such a breach of professional courtesy, but it is never a valid excuse.

WOMEN AS EDITORS

Technical editorial work should offer an interesting and satisfying occupation for women trained in chemistry who have also the required supplementary knowledge of English composition and the mechanics of editing. Time was, at A. C. S. meetings, when any chemist in skirts was assumed to be a teacher; later they were assumed to be literature searchers or librarians. These three occupations do absorb a fair proportion of technically trained women, but they cannot take them all.

There are already many women trained in chemistry who are now serving efficiently in positions of varying responsibility on the editorial staffs of professional journals and trade papers (*8*). Many more such positions should be found for qualified women, seriously interested in the practice of chemistry, who have been squeezed out of the different kinds of chemical and technical work they were doing during the war (*3*, *19*).

CONCLUSION

Despite all the diversity of opinion, then, it would seem that all departments of chemistry could well offer courses in chemical literature and technical writing. Although all students in science and technology could profit by them, women should be encouraged—nay, urged or obliged—to take them, as the entering wedge into interesting and secure non-laboratory positions. Any chemist who may be asked to talk on chemistry as a profession and on the vocational opportunities in this field should always emphasize the broad possibilities of writing as an essential branch of technical service. If it did nothing else, this would at least help to dispel the fog of glamour and romance that surrounds research and discovery as the only ends and outcomes in chemical work.

All these thoughts on technical writing and editorial work bring to mind an earnest talk by the late Dr. Glenn Frank, President of the University of Wisconsin. Addressing a meeting of the Authors League of America, he said:

> In times of business depression, writers are too often inclined to develop an inferiority complex, from the thought that at such times deeds count for far more than words. This I believe to be a mistake because in times of stress, doubt, and indecision, words—powerful words—are needed more than ever, to mould public opinion and to guide wavering minds into the channels of belief in new ideals. These are the times when those that understand the mysteries of science and technology should explain them to others, so that they will be properly appreciated. There is a dire need for good lucid writing on these subjects so that those with funds will be induced and encouraged to invest them in essential research.

That was many years ago, early in the inter-bellum depression, but the present situation is equally critical in another way. More recently (1947), an editorial in the *New York Herald Tribune*, in commenting on a fine exhibition of scientific processes and devices, had this to say:

> Only one thing was missing from the display—some way to help the people to understand these scientific novelties. It is impossible to stop inventing things until everyone catches up, so what is needed is some super-inventor to invent a way of speeding up everyone's understanding of science, of invention, and of what they mean.

The urgent need for intelligent understanding of science can be met only by intelligible writing about science, aimed at all levels of perception. Both in these days and in the future, when there may be questions as to the actual value of chemical research, anyone that can thus bridge the gap between the laboratories and the outer world—whether he or she does original writing or edits the effusions of others—that person should be considered a true missionary for science.

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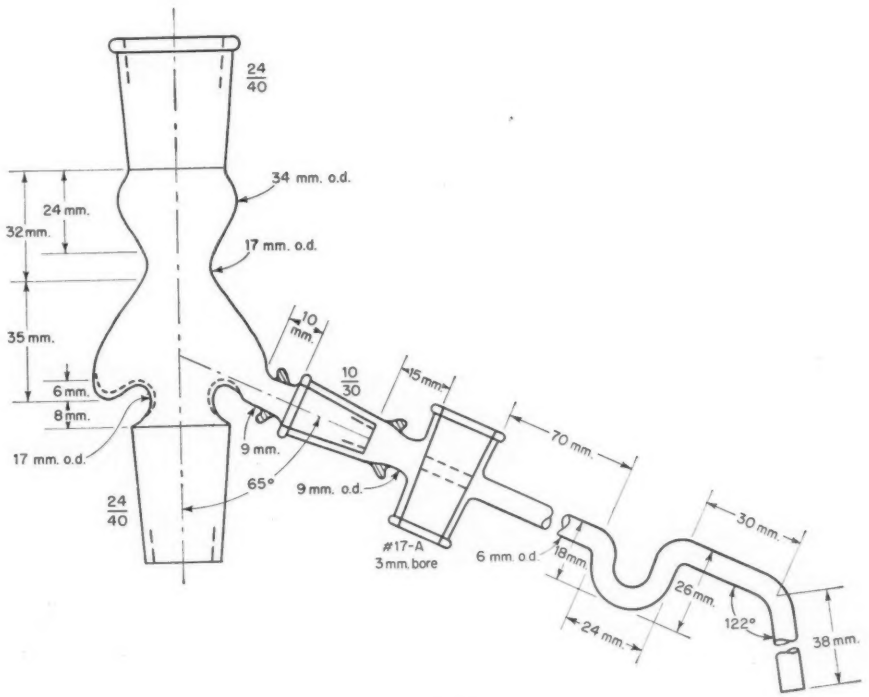
A SOLVENT TAKE-OFF ADAPTER

IRVING ALLAN KAYE
Brooklyn College, Brooklyn, New York



Take-off Adapter

THE take-off condenser described by Fieser,[1] a distinct aid in carrying out crystallizations, is rather unwieldy to store when not in use. The adapter shown in the diagram overcomes this objection and can be used with any of the standard-taper condensers commonly available in the organic chemical laboratory. For most efficient results, the entire reflux assembly is best tilted slightly in the direction of the adapter sidearm.

[1] FIESER, L. F., "Experiments in Organic Chemistry," D. C. Heath and Co., New York, **1941**, p. 323.

THE CHEMICAL LIBRARIAN IN INDUSTRY[1]

IRENE M. STRIEBY
Eli Lilly and Company, Indianapolis, Indiana

THERE is a growing demand for scientifically trained librarians to fill positions in the special libraries of scientific industries. A "special library" has been defined as "...a collection maintained by an individual, corporation, association, governmental agency, or any other organized group, devoted to a special subject and/or stressing specialized service to a special clientele. Special subject departments of universities and public libraries and of the Library of Congress shall be considered as falling in this category" (*1*). The remarks to follow concern library service to the clientele of a chemical manufacturing company, and client refers to anyone who uses the library, regardless of whether the question comes from within or without. Training is used synonymously with education. While librarians have been referred to elsewhere in a number of ways, from clerk to information officer, and from storekeeper to "that person with a multi-dimensional brain," the librarian referred to herein is the administrative head responsible for the type of service described.

A chemical company does not need to be large in order to establish a library, nor do chemistry libraries need to be large in order to give good service. These libraries may fall into any number of organizational patterns. Some are quite limited in scope. They may serve only the scientific research group; they may be attached to the patent, market research, or other divisions of organizations; or they may be integrated as units in company departmentalized library service. A survey of science-technology libraries was made four years ago as a basis for "Technical Libraries: Their Organization and Management," a manual of the Special Libraries Association (*2*). Of the 311 questionnaires returned, 237 libraries were reported as serving the entire company while 74, or less than 25 per cent, served only one department (*3*).

For the purpose of this discussion, the chemistry library is defined as one organized to supply information on a plant-wide basis. This means a multiple function service—to management, industrial relations, marketing, purchasing, accounting, production, research, public relations, engineering, and plant maintenance. If, for a demonstration, the safety department asks where it can rent colored slides of a skeleton, the librarian looks for the address. If the head of territorial operations asks for trade-in values of automobiles in Hawaii, he receives the answer even if it is not found in print. If the office boy requests catalogues of schools offering good courses in chemical engineering, they are given to him even though it is probable he will be in the army within six months. Although a majority of questions referred to the library are concerned with chemistry, pure and applied, there are many that do not have even a chemical slant. Despite the fact that subject concentration bearing on the business it serves is both necessary and desirable, there can be few subject limitations in a library of this type.

Plant-wide service includes every one from the guard at the gates to chairman of the board. To illustrate further, basketball means much to the Hoosier, so once when the Tigers, team of the local Negro high school, reached the semifinals, a porter came to the library during his lunch hour to ask where he might find a large colored picture of a tiger. Luckily for him there was such a picture, clipped from *Fortune*, in the file maintained for the advertising department. In three minutes he departed with the picture to put on his tire cover, his contribution to the pregame parade. Although expendable, the tiger came back all in one piece, plus two coats of floor wax in case of rain. And in this day of developing the best in community relations, as well as in employee relations, such occasional service can be justified as that to the local bank official who needed biographical material on half a dozen scientists under consideration for president of the university whose board of trustees he heads.

It is the prerogative of management to decide what type of library service it needs and is willing to support. Provided it wants comprehensive and efficient service for the entire organization, its first step is to find and to employ the person who can build such a service. Added to personal qualifications, of which there are many (such as innate ability, alertness, imagination, adaptability, initiative, resourcefulness, and a genuine interest in people), the librarian most likely to develop the service to its maximum point of usefulness in a minimum amount of time will possess a broad education and and a varied life experience. There is, of course, no guarantee that a person who presents these, in addition to the specific abilities outlined further on, will be a successful chemistry librarian. Nor does it mean that this preparation entitles one to a feeling of smugness and self satisfaction; the learning process goes on, for new situations call for new skills. It does mean, however, that the person who has this combined competence commands a decided advantage over the person without it.

Familiarity with business information sources is essential in supplying facts to the many facets of a manufacturing corporation. In addition to its recognized need in reference work, sooner or later facility

[1] Presented before the Division of Chemical Literature at the 119th Meeting of the American Chemical Society, Boston, Mass., April, 1951.

in reading foreign languages will be useful in handling scientific and statistical publications of other countries. In mentioning these educational qualifications one at the same time remembers that the majority of libraries in the chemical industry did not develop until the period of World War I, many of them having their origin in space set aside in the general office, with a stenographer devoting part time to the work (*4*). Library development has progressed indeed, but not more than chemistry itself; the story was told a few years ago of how a first university course in chemistry was taught by an elderly theologian for no better reason than the fact that so few students enrolled for theology (*5*).

In order to attain efficient service expeditiously, the library administrator needs proficiency in both library science and chemistry. The more he possesses of each, the more effective he can be in his work. If he lacks a knowledge of both, he has a handicap which he rarely can overcome unless he does something about it. To be sure, there *are* persons who have the capacity to grow on the job, regardless of educational limitations. In fact, there are able librarians who lack formal training of any kind. In comparing professional preparation both qualitatively and quantitatively, one usually thinks first of law and of medicine. But for the sake of variety as well as of pertinence, let us hear what J. Edgar Hoover believes: "Folks have said I over-emphasize the need for educational attainments. They say a man can be a good detective without an education. Granted that this is true, I say a man can be a much better detective if he has a working knowledge of evidence, of court procedure, [and] of the law itself" (*6*).

If the librarian lacks knowledge of library science or chemistry he has a deficiency he may be loath to admit, or perhaps limitations he fails to recognize. It is only when he in some way or another compensates for this gap in training that he is able to develop the best in company-wide library service. While it is essential to recognize that all positions do not require all qualifications, there is no need to stress here the importance of chemistry as prerequisite to some types of positions in chemical libraries—not only chemistry in all its ramifications but also working knowledge of allied subject fields such as physics and biology. It is just as unreasonable for those who have no special subject knowledge to advocate acquiring all of it "on the job" as it is for the subject specialist to believe he can learn how to run the library in one easy lesson. In reading innumerable articles, controversial and otherwise, it is apparent that such attitudes exist.

There is general agreement that it is the function of the librarian to direct the acquisition of all printed and near-print materials likely to be of use to an organization (and sometimes information which is not even in print), to supervise the processes necessary in making these materials available, and finally to aid in their distribution and use. *Endeavour* thus editorialized: "To track down information speedily and successfully requires both a general knowledge of the bibliography of science and a knowledge of modern library practice—in particular, knowledge of the use of card indexes prepared according to conventional systems of classification" (*7*). Indeed, classification is no plaything for the novice. Interlibrary loans often present enigmas; their procedures require strict adherence to a professional code. And in the duel of subject headings that often occurs between those who assign them and those who use them, a command of techniques as well as of subject is needed to meet the criticism voiced by one who complained of the library cataloguer: "It's *see*, and *see also*, and finally *see me!*" (*8*).

Company-wide library service involves much more, however, than acquisition of materials, their organization for use, and aid to the clientele in getting particular facts when they need them. There are plant services for which a real need may exist, such as assistance in choosing books for discussion groups, supervision of branch stations maintained on company premises by the local public library, aid in organizing small departmental collections such as cuts and negatives for the printing department, preservation of company archival material, indexing of company publications, maintenance of both business and scientific periodical abstracting, and answering innumerable questions from individuals that require wide knowledge of general reference sources. In this category even hobbies are helpful and Latin is sometimes of greater aid than is chemistry. It is not the purpose here to be anecdotal by giving further examples of service; this has been done in a paper based on what actually goes on in a number of our largest technical libraries (*9*).

To go back to methods of compensating for lack of special qualifications, some librarians possessing only subject knowledge have found it expedient to ask for a leave of absence in order to acquire professional library training. Other librarians with little knowledge of chemistry have, over a period of time, taken additional academic work—a course of action conceded to be difficult but, nevertheless, a form of compensation. In libraries assigned complex duties requiring more than one man, literature chemists and language specialists are often employed; all work as a team. Management sometimes takes the problem in hand and solves it by attaching literature chemists to various research divisions rather than to the library staff; by establishing departmentalized library service under one administrative head; or by setting up separate business and scientific libraries. In the former, a knowledge of chemistry may not be considered a necessity though certainly it is an asset.

How to prepare one's self adequately for the administration of the type of library service stressed in this discussion, yet keep preparation within limits of what is economically feasible, poses a problem for the individual. First of all, he should keep in mind that, with possession of this desirable combination of qualifications, there is usually opportunity for advancement within an organization. When encouraged by management, libraries usually grow in proportion to the service developed. When this situation does not obtain, there

are opportunities in scores of well-established chemical libraries throughout the country, and in potential ones that will originate during our war economy. A recent survey, involving 25,000 librarians, indicates clearly that average annual salaries for positions in the field of physical sciences are at the top of the list of library specialties (*10*). Further encouragement is given by Working Party III/D of the Royal Society Scientific Information Conference which reached the conclusion that "special librarians with similar academic qualifications and with qualifications in librarianship should also have status and salaries comparable with those of their scientific colleagues in research, administrative or industrial posts" (*11*).

Prior to the beginning of the last decade there were few articles in chemical and library literature stressing the need of specific training for those who chose a career in chemical libraries. The rapid growth of The Special Libraries Association's Science-Technology Division and the development of the A.C.S.' Chemical Literature Division provide the impetus and media to define training needs. There is a growing demand to use the subject approach to the education of librarians. Each year more universities offer a course in chemical literature which a library student can take as an elective. Simmons has, for some time, offered a *program*, not just one course, in preparation for subject librarianship. Recent developments in the field of library education show promise of combining subject specialization with professional training in a five-year program leading to a master's degree (*12*). One plan now attracting attention is offered at Carnegie Library School: a science major is prerequisite to entrance. With bias toward chemistry, the courses in administration, documentation, and bibliography are taught by specialists. There are more positions open for these graduates than there are librarians to fill them.

While the path chemical librarians have followed to achieve their present degree of competence is relatively unimportant, it is true that those best qualified are firmly entrenched in their present positions, hence unavailable to fill either new openings or normal replacement needs. Another decade may pass before there are persons being trained in sufficient number to fill the demand. To encourage young people to choose chemical librarianship as a career, library administrators must present their requirements to library school directors and professors of chemistry in the hope they will help to discover beginning chemistry students who like to work with books, with people, and particularly with the broader applications of library work. Efforts should be continued to articulate what librarians are in terms of what they do. During experience as employment chairman of a library association, both at the local and national level, it was observed that employers often do not know what they want and so look for librarians because librarians traditionally deal with printed material. What they really may want is a literature chemist; they may not be ready to establish a library and give it the support it deserves.

For example, in a recent copy of *Chemical and Engineering News* an advertisement appeared under "Library Work" for a chemist with a good knowledge of organic chemistry and German, with library experience desirable but not required. Directly beneath it was another for a "Literature Searcher" with the combination of chemistry and languages (*13*). In the event a chemist qualified for both positions, application could be made for the latter with a far greater feeling of assurance. In the case of the former would the person, if chosen, administer the library? If so, where would he learn how? Is there a library already established or would he be expected to organize it? If a librarian is already in charge of the library, to whom would the chemist report? Far more revealing was an earlier advertisement in the same journal which stated that the opening for a literature searcher was not to be confused with that of librarian; a chemist or chemical engineer who uses the library as a research tool was sought (*14*). To be a successful librarian one must want to be a good librarian and study hard at it, rather than want to be something else and train for that.

This discussion has not been concerned with reporting and analyzing reference work of a strictly chemical nature that is performed in varying degrees in all of our chemical libraries. This has been done by Mellon in "Questions a chemist takes to the library" (*15*), by Dickison in "Let your librarian look it up" (*16*) and in a number of other articles. On the other hand, there has been an attempt to emphasize that the library giving plant-wide service must be staffed to handle not only the questions related to the subject field of company interest but also those in peripheral fields and even those in areas having nothing whatsoever to do with chemistry. To do this the librarian needs high educational and personal qualifications. In the event he cannot offer all, he may seek complementary skills in other library staff members or he may attempt to compensate for his deficiency in some other way. Lack of educational opportunities for positions of this type has been a handicap. This situation shows promise of correcting itself; for the pioneering efforts in this direction there should be increased recognition and support.

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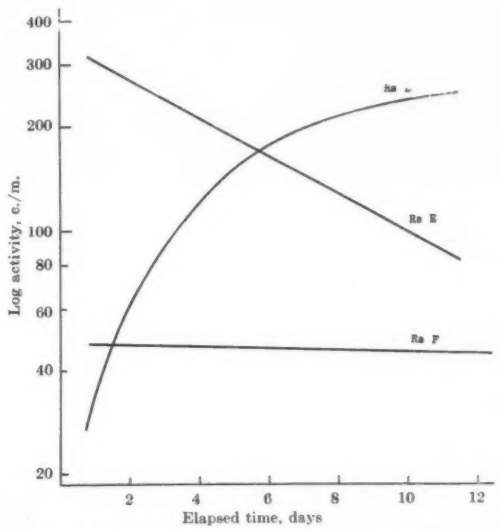
SEPARATION OF RADIUM D, E, AND F BY PAPER CHROMATOGRAPHY

EDGAR E. DICKEY
The Institute of Paper Chemistry, Appleton, Wisconsin

THE chemical separation of radium D, E, and F is comparatively simple and is a useful exercise for students in radiochemistry. But a simpler and more convenient separation may be accomplished by paper chromatography. The chromatographic procedure was adapted from the general method of Rutter[1] as employed by Rao and Beri[2] for common sugars. The chromatograms are suitable for the preparation of radioautographs, they may be sectioned and counted, or the sections may be eluted.

A solution of radium D, E, and F was prepared by dissolving one spent radon seed (in a gold capsule, furnished by the radium Service Corporation of America, Chicago, Illinois) in 0.4 ml. of aqua regia. An amount of the yellow-colored solution sufficient to produce approximately 5000 counts per minute was spotted on Whatman No. 1 filter paper (18 cm. in diameter) approximately 15 mm. from a wick at the center of the paper. A similar spot was placed at another point in combination with small amounts of solutions of lead and bismuth nitrates. The paper was air-dried and was placed in the irrigating apparatus, which consisted of two Petri dishes (15 mm. in height by 50 mm. in diameter, and 22 mm. in height by 150 mm. in diameter) covered with a glass plate. The smaller dish was placed inside the larger and was half-filled with *n*-butanol saturated with aqueous *N* hydrochloric acid.[3] After approximately two hours, the paper was air-dried and was exposed for a few minutes to moist ammonia and then to moist hydrogen sulfide. Two brown spots appeared in the carrier-bearing chromatogram, one (lead) near the starting point and the other (bismuth) midway between the starting point and the prominent yellow spot of gold. The carrier-free chromatogram, as expected, produced no visible spots for lead and bismuth. The chromatograms were sectioned with a razor blade and the pieces of paper were counted under a thin-window G-M counter. The results are shown in the figure. Thus, radium D (Pb) remained near the starting point, radium E (Bi) moved approximately halfway down the chromatogram, and the radium F (Po) was located between the radium E and the gold.



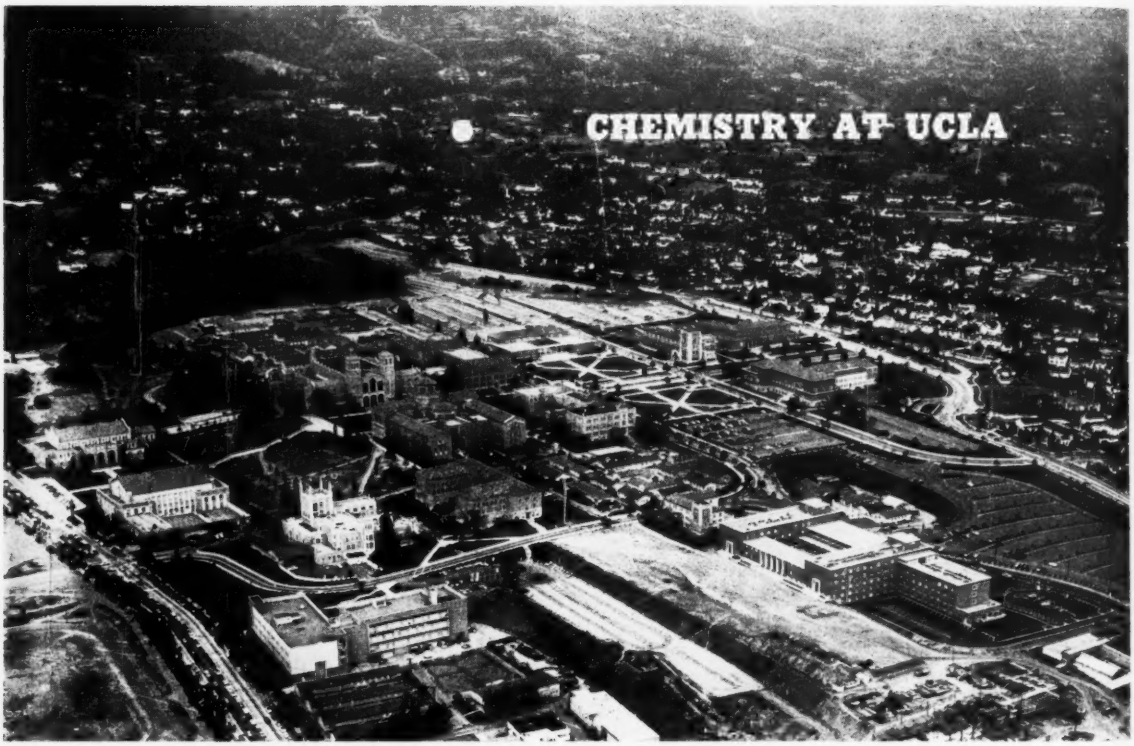
Activity of Radium D, E, and F Separated by Paper Chromatography

Larger scale chromatograms were readily obtained with strips of paper in the conventional type of apparatus. These chromatograms were quantitatively eluted with *N* hydrochloric acid by the technique of Dent.[4]

[1] RUTTER, L., *Analyst*, **75**, 37 (1950).
[2] RAO, P. S., AND R. M. BERI, *Proc. Indian Acad. Sci.*, **33**, No. 6, Sec. A, 368–72 (1951).
[3] LEDERER, M., *Nature*, **162**, 776 (1948).
[4] DENT, C. E., *Biochem. J.*, **41**, 240 (1947).

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION
OF CHEMISTRY TEACHERS



Main Group of Buildings on UCLA Campus, Showing New Chemistry Building in Lower Right Corner

G. ROSS ROBERTSON
University of California, Los Angeles, California

At the outset of professional training in chemistry on the Los Angeles campus of the University of California a comprehensive set of requirements was listed, and this proved to be in rather close agreement with the standards more recently recommended by the A. C. S. committee. For the bachelor's degree, four solid year-courses—general, quantitative, organic, and physical—are required, together with the usual physics, mathematics through integral calculus, and three semester-courses in German. In addition, two semester-courses in advanced chemistry and a substantial minimum program in liberal arts are included. Most recently the requirement of a course in technical written English has been added, at advanced rather than elementary level.

During the 1920's UCLA emerged from junior-college status, and began to award bachelors' degrees. By Regents' ruling, graduate study was forbidden. During the 1930's the master's and doctor's degrees were added, soon followed by postdoctoral fellowships. These changes rendered the original "permanent" chemistry building of 1929 obsolete. To make a long story of finance and planning short, a new building housing chemistry and geology, costing over $4,000,000 was occupied in the summer of 1952. Special features of the UCLA chemistry department may thus be best explained on the basis of the new building design.

The unusual requirement, laid down by the administration, that a building for the two entirely distinct departments of geology and chemistry be constructed, proved after all to be an advantage, not a hindrance. A generous layout of five lecture halls could be justified,

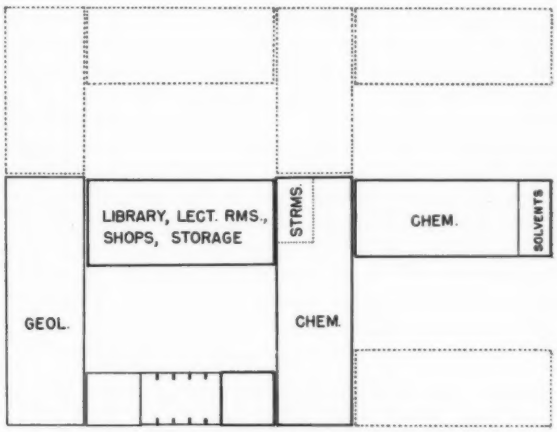
giving flexibility in class assignments. Advantage was taken of the temperate climate of west Los Angeles (almost never below 32° F.) to place all public entrances and exits of large lecture halls outdoors. There is accordingly no hourly traffic jam in laboratory buildings, and architect Gordon B. Kaufmann was thus able to cut two feet off conventional corridor width in those buildings. The general design outlined in the figure shows the library-lecture-hall-shop-storeroom structure as a bridge between the otherwise entirely separate chemistry and geology sections. Dotted areas indicate provision for future construction somewhat in excess of present laboratories.

"Net useful" area allotted to chemistry is shown in the following statistical summary. By "net useful" is meant the net floor area of rooms used for department functions, exclusive of stairways, corridors, walls, etc. In this building the net yield is about 75 per cent of gross floor area often reported in building records. "Number of laboratory workers" means the total number of such persons in all classes or laboratory programs who appear at some time in the week when enrollment is at full capacity.

Function	*Number of laboratory workers*	*Net useful area, sq. ft.*
Central department administration	...	1,555
Freshman laboratories and balance rooms	1,488	10,335
Quantitative laboratories and service rooms	378	6,175
Organic laboratories and service rooms	446	6,175
Physical chemistry laboratories and service rooms	164	3,770
Biochemistry laboratories and service rooms	90	2,600
Instrumentation laboratories and service rooms	64	2,050
Graduate students' laboratories	104	16,300
Postdoctoral laboratories	13	2,400
Laboratory-office suites for 24 faculty members; space approx. 1/3 for office, 2/3 for laboratory	24	12,965
Small offices for visiting scholars, adjacent to the chemistry library	...	260
Work spaces (approximate estimate) for additional graduate students and postdoctorate workers accommodated in faculty laboratories	25	.....
Miscellaneous special research laboratories and instrument rooms (nuclear, X-ray, mass spectrometry, etc.)	...	5,990
Library	...	3,740
Classrooms, permanent, chemistry's share	...	8,675
Classrooms, temporary, future library space	...	1,350
Shops: machine, electronics, glass, and students'	...	3,400
Storerooms, dispensing	...	5,370
Storerooms, receiving and case storage	...	10,600
Storerooms for dangerous chemicals, inflammables	...	1,250
Solutions preparation and storage	...	1,550
Miscellaneous	...	2,340
Total net useful area, chemistry		108,850

UNDERGRADUATE CHEMISTRY

The first year's trial of the single-section laboratory plan, introduced many years ago by Lewis, Bray, and Hildebrand at Berkeley, has given great satisfaction. Ten rooms, each accommodating one instructor and 24 or 25 students, take care of all performances except the more formal lectures to large groups in lecture halls. For example, a section of "Chemistry 1A" meets at 1:00 P.M., Tuesday and Thursday. An undisturbed class discussion, problem session, or written examination lasts until 1:30, 1:45, or 2:00 P.M., followed by laboratory work normally requiring attention of students until 4:00 P.M. The instructor remains one additional hour, to 5:00 P.M., to aid slow performers, and no other laboratory time, particularly no unsupervised time, is allowed in the course.



General Plan of Chemistry and Geology Buildings at UCLA

The six separate structures prevent excessive hazard during possible earthquake. Dotted areas indicate plans for future construction.

Although this system of single section in a separate room is used in a few places in the far West, and more recently at Columbia University, it has not yet met favor in the Midwest, perhaps for economic reasons if nothing else. Southern California, however, has the advantage of a large junior-college system. This, together with the requirement of A or B high-school record for admission to the state university at freshman level, relieves UCLA of a great deal of the mass-education problem in freshman and sophomore chemistry. In October, 1952, 45,275 students were enrolled in public junior colleges in Los Angeles County alone. As a result, the freshman class at UCLA was the smallest of the four college classes, with the senior 46 per cent greater than the freshman, and the graduate group topping all. To be sure, the enrollment of 565 in Chemistry 1A, in the fall of 1952, out of a gross student population on the Los Angeles campus of 13,397, probably looks undersize to an Ohio or Illinois state university administrator. Some prophets even foresee shrinkage of the freshman chemistry enrollment until only a "pilot-plant" group is accommodated, but this, if at all likely, is something for the distant future. There is evidence which indicates that about six per cent of the high-school graduates of California will go directly to some campus of the University regardless of the establishment of junior colleges or other factors.

Quantitative analysis, organic chemistry, and physi-

cal chemistry follow standard procedures as far as "table of contents" is concerned. A section of the department devoted to biochemistry operates distinct from the medical school. Instrumentation, just now started, takes its place beside the other main topics with a special elective undergraduate laboratory course, served by both a faculty member and a technician. Introduction to various types of spectrometry, polarography, polarimetry, etc., aims to give the senior student an advantage in service to both industrial and academic employers. Principles of operation are stressed.

In beginning organic chemistry a special 10-credit, year-course sequence is required for chemistry majors. This course uses standard-taper glassware and modern electric accessories. Since much of the research in organic chemistry is in the field of physical organic chemistry, it is not surprising that physical concepts and basic ideas of the mechanism of reaction are introduced in this beginning course. Main emphasis still remains, however, on necessary fundamentals of synthetic methods and interpretation of structure. More thorough study of the "physical organic" concepts is left to the six-credit, one-year sequence of lectures in advanced organic chemistry for seniors and graduates. Non-chemistry majors take different organic courses.

ECONOMIES IN BUILDING DESIGN

Aside from the conventional services distributed to laboratories, a few items were designed with special attention to reduction in cost per student.

Aisle space next to windows of laboratories was cut from common values, running as high as 5 feet, to 21 inches. Convenience to instructors, and the emergency factor, led to rejection of the peninsula design, which would have afforded still greater saving.

Every laboratory worker from freshman to professor has direct access to at least one sink; there are no troughs in the entire building. No pipe, flue, conduit, cup sink, trough, or any other kind of passageway for a fluid is located inside any laboratory bench. All service pipes come from the ceiling. This eliminates the large, wasteful central space normally found in all present-day commercial "island benches," and allows much deeper, though, of course, no more convenient lockers. Lockers 18 inches wide, drawer and cupboard, thus replace the 24-inch shallow lockers often used elsewhere. This system requires special drains on top of benches. For this purpose the Harvard plan (Mallinckrodt Laboratory) was followed, with substitution of the newer "streamline" copper tubing, with bull-head tee openings, for the common pipe which was the only material available during the Harvard construction.

No direct-current wiring is installed except in the immediate vicinity of the physical chemistry laboratories. Direct-current requirements in other laboratories are provided by portable transformer-rectifier units. This plan eliminates most of the very expensive direct-current conduit systems and switchboards.

GRADUATE STUDY

Graduate students in chemistry at UCLA come from many institutions, as shown in the tally sheet for September, 1952, of which the following is a summary:

Undergraduate Training

Eastern universities	12
Eastern colleges	3
Midwest universities	25
Southern universities and colleges	3
Mountain states universities and colleges	5
Pacific universities (outside U. C.)	6
Pacific colleges	8
Canada	3
Mexico	1
Europe	2
Asia	2
University of California (Berkeley)	12
UCLA	22
Total	104

In future years it is hoped that a better representation of small colleges may be attained, preferably at the expense of the last item on the list. The presence of UCLA in a very large city probably tends to boost the local figure. Uncertainties of draft procedures give similar trend. The newness of the graduate program is probably reflected in the small showing from colleges where UCLA is not yet well known.

A wide variety of research problems, open to the graduate student, is suggested by the following much-abridged list: amperometric methods of analysis; polarography; potentiometry in ortho-semidine systems; macro-ring compounds; comprehensive study of acetylenic systems; "neighboring group participation" in organic reactions; chemistry of plant pigments; mechanisms of reaction in allylic systems; thermodynamics of aqueous and nonaqueous solutions; experimental and theoretical treatment of molecular interaction in adsorbed phases; X-ray diffraction applied to both organic and inorganic problems; photochemical reactions; isotopic exchange reactions; isotopes from the cyclotron; chemical and microbiological problems related to amino acids, and metabolism of microorganisms. More detailed information, not only on topics of study, but also as to administrative arrangements is available upon application to the Graduate Adviser of the Chemistry Department.

The usual "normal" period of study of about one year for the M.S., or three years for the Ph.D., is applicable, provided the attention of the candidate is not diverted by remunerative work outside the graduate course and research requirements. Both the M.S. and Ph.D. degrees require completion of a research program, with dissertation to be filed in the local libraries. If a newcomer qualifies for research, he may start at once, there being no arbitrary initial period confined to course work.

Seminars allow public appearance of both local and visiting scholars, including postdoctoral fellows and graduate students. Individual staff members hold more informal colloquia in addition.

Monthly "cumulative" examinations are given in the

major field of concentration. Graduate students who have already met the standard B.S. requirements take these examinations until seven have been passed, as a regular requirement in candidacy for the doctor's degree. This normally requires about one and a half years. If the graduate student has met only the minimum requirements for the B.S. in chemistry, he will probably be required to take certain advanced courses, possibly including qualitative organic analysis or one of the three "advanced" courses in analytical, organic, and physical chemistry.

Approximately 50 teaching assistants are employed, the present compensation being $1500 for the 9-month academic year; 12 to 15 hours of teaching service per week are normally expected. In addition, special subsidies are available. The tuition fee normally required of non-residents of California by state law may be remitted in whole or in part, at the discretion of the Dean of the Graduate School, for graduate students who have distinguished scholarship records and carry full programs. An "incidental" fee is charged at registration time, but there are no laboratory fees.

Aside from numerous general facilities, each graduate student has 9 to 12 lineal feet of laboratory bench and a small office desk for individual use. Such workers are served by seven skilled craftsmen in machine, glass, electronics and instrument shops. Two full-time and various part-time technicians maintain laboratories for organic analysis and solution preparation. The chemistry library has complete sets of most of the journals in pure chemistry and biochemistry, and receives 190 current journals.

Major items of equipment now available for graduate research include numerous types of specialized instruments for radiochemical and nuclear research; a recording mass spectrometer; quartz and fluorite optical systems for photochemical research; infrared and ultraviolet spectrophotometers, including recording instruments; a precision bridge for measurement of conductances of nonaqueous solutions; X-ray diffraction equipment; a Gouy magnetic balance; recording polarographs; precision polarimeters; high- and low-pressure hydrogenation equipment; a number of precision fractionating columns; chromatographic fraction collectors; and a Warburg respiration apparatus.

In other departments on the campus are found such equipment as electron microscopes, a 42-inch cyclotron, and considerable equipment for difficult problems of computation. Of special interest is the Institute for Numerical Analysis of the National Bureau of Standards, located on the campus.

Space for 13 postdoctoral fellows is provided in special laboratories, each for one or two persons, with space for other postdoctoral fellows in faculty laboratories as the staff may choose. Research grants have enabled the department to invite persons in this category not only from American laboratories, but from abroad.

A FILM ON THE ANALYTICAL BALANCE

A 16-mm., black-and-white sound-film, entitled "The Analytical Balance and Its Use," has been produced by the University of Illinois with the cooperation of Fisher Scientific Company. This film, for instructing students in the use of the balance, saves the time required to teach them individually and permits standardization of instruction in the technique involved.

The film makes use of diagrams as well as showing the actual operations. It covers the construction of the balance, theory of balance swing and practical determination of rest points, weighing, and special types of balances.

Inquiries concerning purchase of a print or rental may be addressed to Mr. Lewis V. Peterson, 119 Gregory Hall, University of Illinois, Urbana, Illinois.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

CHEMISTRY OF THE COVALENT BOND[1]

The First-year Course at Brown

LEALLYN B. CLAPP
Brown University, Providence, Rhode Island

THE general outline of the chemistry program in effect at Brown University for the past five years has been described previously.[2] In that paper the first-year course was referred to in terms of traditional courses as organic chemistry. It is the purpose of this article to indicate how the course differs from carbon chemistry. The title given to the course, "The Chemistry of the Covalent Bond," is quite descriptive. Of the three types of bonds occurring in compounds: electrovalent, covalent, and coordinate covalent, the largest number of examples of covalent bonds comes from carbon compounds, so most of the time is spent on them. However, the responsibility of the course is not to the field of organic chemistry but to *chemistry*. The main differences between a beginning organic chemistry course which the author has taught and the present one are the following:

(1) The background for emphasis on structural chemistry is laid more carefully.

(2) A discussion of the "evolution of the covalent bond" is included.

(3) Acids and bases are treated more fully.

(4) Balancing oxidation-reduction equations is emphasized.

(5) The chemistry of covalent compounds with a single central atom is treated as the chemistry of functional groups rather than as the chemistry of one element at a time.

Each of these differences will be commented on presently.

The most significant characteristic of the covalent bond, that it is a directed valence, becomes the all-enveloping central idea of the entire first year. At the beginning the student is asked to accept the following postulates as a basis for building a structure of concepts:

(1) That carbon is tetracovalent.

(2) That the four bonds are directed toward the vertices of a regular tetrahedron, making angles of 109°28′ with each other.

(3) That carbon may be joined to other carbons in stable linkages—almost a unique property among the elements.

The geometric implications of these postulates are examined and examples are given from atoms other than carbon known to be tetrahedral. The student early gets the impression that geometry is important in chemistry through the phenomenon of isomerism and an appreciation of the principle of economy of explanation—for example, in learning the properties of individual members of a homologous series. The desirability of introducing structural chemistry early is being recognized in general chemistry courses now, as one may gather from some recent textbooks.

With this structure of concepts the student learns the properties of the common functional groups. This takes half a year studying aliphatic and aromatic compounds concurrently. At the beginning of the second semester the foundation is firmly established under the structure of concepts, since the student is now enabled to prove to himself that the original postulate of the tetrahedral carbon is sound. The convincing evidence and final proof comes from an examination of the implications of optical and geometric isomerism. While it is not desirable in a science course to wait so long to establish initial premises, there appears to be no alternative unless the first chapter is made interminably long.

At the beginning of the second semester the flashback technique is used further to examine what is called "the evolution of the covalent bond." A brief look into the paths of thought which led to the present idea that atoms are joined together in molecules is eventually brought to conclusion in the G. N. Lewis theory of the electron-pair bond. This history is difficult reading mainly because the student knows too much chemistry by this time. Once the concepts of atoms, molecules, and electrons have been used throughout a year of high-

[1] Presented in part at the 269th Meeting of the NEACT, Mary C. Wheeler School, Providence, Rhode Island, February 14, 1953.

[2] COLES, J. S., L. B. CLAPP, AND R. P. EPPLE, J. CHEM. EDUC., **26**, 10 (1949).

school chemistry and a semester in college it is difficult for him to separate himself from these ideas to become an unprejudiced observer of 1850. (It is equally difficult for his teacher.) Perhaps the principal accomplishment in this endeavor arises from getting students into the stacks of the library to get an inkling of what is meant by an original source. By a few selected readings one comes to appreciate the impact on scientific thinking by the ideas beginning in 1828 with the synthesis of urea, followed by the theory of radicals, substitution, and dualism, and the theory of types. This succession of theories culminated in the theory that there were bonds within molecules. By 1860 a clear distinction between atoms and molecules had been drawn for the first time and Kekulé's structure for benzene followed. Our present modification of Kekulé's structure in G. N. Lewis' electronic picture and an introduction to resonance brings this section of the course up to date.

During the first semester acids, bases, and hydrolysis are treated more thoroughly than in the usual organic course. Three definitions of acids and bases are extolled—Arrhenius, Brönsted-Lowry, and Lewis—as being useful in various situations. Examples are taken from mineral and carboxylic acids and from hydroxylic and amine bases. Hydrolysis of salts according to Brönsted and acid hydrolysis of olefins and acetylenes in the Lewis sense are treated in the most general terms, but hydrolysis involving complexes is left for a later course, as is the quantitative treatment of the subject.

In the subject of oxidation-reduction, the pitfalls of variable valence cannot be avoided but the students are protected by using only three oxidizing agents—permanganate ion in basic or acid solution and dichromate ion in acid solution—for which they learn the changes in oxidation number. The reducing agents are almost entirely organic, containing the ordinary functional groups. The bulk of inorganic oxidation-reductions are left for a later course, but enough examples of balancing equations are given so that the student gets a feeling of confidence in his own ability to tackle any such exercise. A hybrid combination of the methods of Gregg,[3] Ferguson,[4] and Glasstone[5] is used for determining oxidation numbers in carbon compounds and the ion-electron method is used for balancing equations.

The greatest asset in teaching the chemistry of the covalent bond to freshmen is the initial enthusiasm which they bring to a course content which is new and different from their high-school course. The innovation in the course content itself for which a strong brief is held is the chemistry of covalent compounds with a single central atom, mainly some chemistry of nitrogen, silicon, phosphorus, sulfur, and halogens. This constitutes about three weeks' study in the second semester, in which most of the time is spent on polyfunctional compounds investigating the influence of one group on another in the same molecule. The chemistry of the nonmetals just mentioned is discussed at length elsewhere.[6]

The year-course described here entails three lectures per week, one recitation, and six hours of laboratory in two sessions. The laboratory experiments involve the usual techniques of organic chemistry including steam distillation and distillation at reduced pressure but fewer "still-pot" experiments. The student does an acid-base titration, gets an introduction to the use of the balance, does a volumetric oxidation-reduction titration of oxalate ion with permanganate ion, prepares an anhydrous covalent halide such as tin tetrachloride, phosphorus trichloride, or sulfur monochloride, and handles glassworking to the extent of sealing off a volatile liquid, generally nitrogen dioxide which he has generated himself. These last two sets of experiments have been standard in inorganic courses at Brown for many years.

From the viewpoint of an organic chemist one may well ask, "what is lost in such a course if six weeks or so is spent on topics not usually included in organic chemistry?" The answer is that fewer organic reactions are learned. Heterocyclics are slighted, fewer aromatic condensations are studied, and less time is given to petroleum and coal tar. However, students from this course enroll in the third semester qualitative organic course which is given to others with a regular year of organic.

The same final examination has been given to the students in this course and the regular organic course for A.B.'s and pre-meds for three years. The freshman average is 5 to 6 percentage points lower on the basis of 100 than the others (sophomores and juniors).

Other people have looked in the direction we are taking. As long ago as 1920, Norman R. Campbell[7] said that one might well start the study of chemistry with stereoisomerism. The following quotation is out of context but I think not removed from the spirit of his suggestion: "For chemistry, so rich in laws (though not often explicitly named as such) and so powerful in the ordering of facts, is poor in theory. . . . Chemistry has but one noteworthy theory and but one set of hypothetical ideas, the theory of combination of atoms into molecules with its fundamental idea of valency. It is a most beautiful theory, surpassed by none other in the intellectual satisfaction it affords, but unfortunately it is not easily or certainly applicable to the compounds in which the attention of the elementary student is concentrated; we know far less about the constitution of water than about that of some organic compound with a name a yard long—long simply because the theory is so strictly applicable to it. If chemistry is to be the vehicle of elementary instruction in science, we should begin with stereoisomers and proceed (if we have time) to the simple compounds of oxygen, hydrogen, and nitrogen."

Recently Sir Robert Robinson made a special plea in

[3] GREGG, D. C., J. CHEM. EDUC., 22, 548 (1945).
[4] FERGUSON, L. N., *ibid.*, 23, 550 (1946).
[5] GLASSTONE, S., *ibid.*, 25, 278 (1948).
[6] CLAPP, L. B., *ibid.*, in press.
[7] CAMPBELL, N. R., "Physics—The Elements," Cambridge University Press, London, 1920, p. 225.

his address to the Science Masters' Association, London, on January 4, 1951, for the introduction of organic chemistry earlier into the curriculum and cited the following five reasons, pertinent in part at least to the present discussion:[8]

(1) The underlying principle of the molecular theory finds the best illustrations in carbon compounds.

(2) Organic chemistry is fundamental for plant and animal physiology as well as medicine.

(3) A large part of physical chemistry, especially the classical approach to chemical kinetics, is concerned with the properties and reactions of carbon compounds.

(4) The subject is of great industrial importance.

(5) Finally, and most cogently, there is the fascination of the work for its own sake.

[8] ROBINSON, R., *School Sci. Rev.*, **33**, 2 (1952).

To the Editor:

I have used a technique for the Hittorf transference-number experiment which represents a hybridization of the Levy (J. CHEM. EDUC., **29,** 384 (1952)) and Angus (*ibid.*, **30,** 155 (1953)) ideas. This method is *approximate* and its pedagogical value lies in the student's making a rigorous analysis of the approximations involved.

The anode and cathode compartments are drained into dry 100-ml. flasks and then filled to the mark with distilled water measured with a buret. Analysis is carried out in any appropriate manner. The drainage is neglected. Let V be the volume in ml. of H_2O added to the flask, e the total equivalents found in the flask, N the normality of the original solution, Δe the apparent change in the number of equivalents in the compartment, and f the number of faradays during electrolysis. Then

$$\Delta e = (100 - V)N/1000 - e$$
$$t = (f \pm \Delta e)/f$$

By assuming that the drainage-loss solution has the same composition as the solution drained off and that there is no volume change during electrolysis the student can show that

$$\Delta e' = \Delta e(100 - V - \Delta V)/(100 - V)$$

where $\Delta e'$ is the true change in the number of equivalents in the compartment and ΔV is the ml. of solution lost due to drainage. Experimentally, ΔV is found to be less than 0.1 ml. for well-cleaned cells. Since V for the usual apparatus is about 90 ml. the error in t is of the order of 0.001. While this method uses concentrations the required error analysis insists that total equivalents be considered for the more rigorous derivation.

ROBERT H. LINNELL

AMERICAN UNIVERSITY OF BEIRUT
BEIRUT, LEBANON

To the Editor:

I am writing with reference to the article entitled "The algebra of simultaneous equilibria," by D. Davidson and K. Geller, which was published on page 238 of the May issue of the JOURNAL OF CHEMICAL EDUCATION. Like that by R. N. Boyd [J. CHEM. EDUC., **29,** 198 (1952)], which it criticizes, this article is concerned with the question of teaching students how to "solve" problems involving more than one equilibrium constant.

The equilibrium constants involved, and their combinations, here presented as final simple solutions of the "problems," are simple algebraic equations. Given such an algebraic equation, or set of algebraic equations, the student presumably knows, from high-school elementary algebra, how to substitute numerical values and calculate an unknown. This "algebraic operation" is not a chemical problem; certainly it is not a problem of chemical education, but rather of elementary algebra and simple arithmetic.

The chemical question is whether or not the final simple algebraic equation applies, in its simple form, to the particular equilibrium problem under consideration. The subject of the "solving" of problems in college courses should be concerned not with algebraic substitution in a simple formula but with the question of the applicability of the formula. If only the simplest formulas or simplest approximations are taught and used, it is up to the instructor, in testing his students, to make sure that his test problems can legitimately be solved by these simple formulas. The result is that the student is tested on algebraic and arithmetical manipulations, while the instructor is being self-tested in chemical principles and chemical judgment.

The significance of these criticisms may be seen by specific reference to the 14 "problems" used as illustrations in the article by Davidson and Geller. Six of these problems, Nos. 4, 5, 6, 8, 10, and 12, require merely the statement of the definitions and their combinations as algebraic equations. No. 14, the calculation of the concentration of zincate ion when zinc hydroxide "is equilibrated with 0.1 *M* sodium hydroxide," is also merely a question of the definitions, if "0.1 *M* sodium hydroxide" means the final concentration of hydroxyl ion. The simple solutions presented for these seven problems, therefore, are explicit and exact, and may be said to apply correctly, by definition, for all possible values of the numerical data. In each case the solution involves no approximations or assumptions; it requires, in other words, no appraisal of the situation, no exercise of judgment.

The remaining seven problems, on the other hand, do involve assumptions and approximations, requiring appraisal of the relations to ascertain that the simple solution used is applicable to the situation. These assumptions and approximations, however, are not stated in the article. Hardly a student reading the article will be aware of them, or will realize that the final simple solution presented applies only for certain values of the numerical data. In fact, there will be more than one instructor who will not realize these limitations.

Problem 1, the calculation of the pH of sodium bicarbonate solution, is based on the product of the ionization constants of a dibasic acid, or $K_1K_2 = [H^+]^2[D^{--}]/[H_2D]$, a combination of definitions. In the previous discussion, the authors write "if $[H_2D] = [D^{--}]$ (which is true in an aqueous solution of NaHD)," the result is, of course, $[H^+] = \sqrt{K_1K_2}$. Although this final formula is unquestionably very useful, the student should know that it is based on the *assumption* that $[H_2D] \cong [D^{--}]$. He should know why this approximation holds well for $NaHCO_3$ but not for $NaHSO_4$ or NaHS, and how and why it holds better for high than for low concentrations. The assumptions made under Problem 2, for the pH of ammonium cyanide solution, are almost exactly analogous to those of Problem 1. The interesting question is that of the range of applicability of these assumptions, not the "algebraic solution" of the final approximation.

Problem 3 asks for the ratio of the complex ions $[Ag(CN)_2^-]$ and $[Ag(NH_3)_2^+]$ on addition of 0.01 equivalent of silver ion to a solution "containing one equivalent each of cyanide ion and of ammonia." With

$$[Ag(CN)_2^-][NH_3]^2/[Ag(NH_3)_2^+][CN^-]^2 = {}_iK_1/K_{i_2}$$

by definition, the answer is given as K_{i_1}/K_{i_2}. But what would the student do for something like the addition of 0.01 equivalent of silver ion to a solution containing 0.01 equivalent of cyanide ion and 0.02 equivalent of ammonia, or to a solution containing 0.01 equivalent each of cyanide ion and of ammonia—particularly, in these cases, if the two instability constants were nearly equal? The real question in "solving" this problem is whether or not we *may* cancel out $[NH_3]$ and $[CN^-]$, not the algebraic difficulty in calculating the answer *if* these concentrations may be cancelled.

The student would be, chemically speaking, much more educated if he knew how to think through, even slowly, the general problem in one general case, than he would be if he knew how to "solve" glibly a hundred problems suitably arranged by the instructor for the applicability of the approximate solution, so as to require no real thinking on the part of the student.

Problem 7, for the pH "of a saturated solution of barium carbonate in 0.02 *M* barium chloride," is based on the combination of definitions

$$K_{sp}K_w/K_2 = [Ba^{++}][HCO_3^-][OH^-]$$

Then, the authors write, "since HCO_3^- and OH^- ions are formed in equivalent amounts," it follows that

$$[H^+]^2 = (0.02)K_2K_w/K_{sp}$$

But it is not pointed out that it is being *assumed* that $[HCO_3^-] \cong [OH^-]$, and that the assumption holds only approximately and only for certain values of the data. If the student assumed the same approximate solution of the corresponding problem for zinc sulfide in 0.02 *M* zinc chloride, for example, he would calculate $[H^+] = 1.3 \times 10^{-4}$ (for the values of the constants as used in the article), an obviously absurd result.

In problem 9, for the concentration of ammonia required to dissolve 0.01 mol of AgCl per liter, the assumption is simply that K_{sp}/c may be neglected relative to c, the number of mols of silver chloride being dissolved per liter. This is quite generally valid for AgCl, although it would not do for $AgBrO_3$ or Ag_2SO_4.

In problem 11, x mol of AgCl is shaken with 1 liter of NaBr solution of molarity c, and the student is to calculate the proportion of sodium bromide converted to silver bromide. The answer given is based on the simple relation $[Cl^-]/[Br^-] = K_{sp}/K_{sp'}$, holding if the solution is saturated with both salts. But unless x is greater than a certain value, the solution is saturated only with AgBr. For $c = 0.1$ the required value of x is 0.09952 (for the constants as used in this article), so that with $x = 0.1$ the answer given does apply. But given $x = 0.09$, for example, what principle will the student use to see whether the "solution" of the problem is applicable?

In Problem 13, the pH at which zinc sulfide will dissolve to form a 0.1 *M* Zn^{++} solution is to be calculated. By definition,

$$[Zn^{++}]/[H^+]^2 = K_{sp}/K_1K_2K_s$$

in which $K_s(= 0.1)$ is the concentration of unionized H_2S in a solution saturated with H_2S. It happens that if ZnS dissolves to form 0.1 *M* Zn^{++}, the total concentration of the dissolved forms of H_2S will be 0.1 so that the solution will be practically saturated with H_2S if $[H^+]$ is not very low, and then the above expression will just apply. But if the problem had called for 0.01 *M* Zn^{++}, the equation would be absurd; and

yet the limitation to saturation with H_2S is not even mentioned.

Neither historically nor in practice is qualitative analysis, for which these problems are apparently presented, based on such calculations for its development or application. These "problems" are introduced, it is agreed, for their usefulness in the teaching of theoretical principles, because the understanding of the principles is proved, ultimately, only in their application to real problems. But for a real problem the student then should decide for himself whether a particularly simple final approximation is applicable to the data. This is the test of the understanding of the chemical and mathematical relations involved. The rest is numerical substitution, non-chemical activity.

If then we concern ourselves with making up problems which will be assumed in advance to conform to the simplest final approximations, the student need only follow certain simple typical procedures to "solve" them. Such problems become essentially algebraic exercises without chemical significance; in a sense the answer to the problem is already assumed in the very form of the final approximation used. In doing this we may succeed in making life easier for the student (and for the instructor) while in school. But in thus avoiding the necessity for the student to think for himself, we misrepresent the real nature of chemical problems and fail in our purpose of fundamental training.

JOHN E. RICCI

NEW YORK UNIVERSITY
NEW YORK, NEW YORK

To the Editor:

Professor Ricci's above letter concerning the recent paper by myself and K. Geller may be considered to consist of two parts: (1) a general criticism of the problems used in qualitative analysis; (2) specific criticisms of the problems given in our paper. Concerning the first part, our own experience suggests that the capacities of second and third term chemistry students fall somewhat short of Professor Ricci's estimate. Such students require considerable drill in applying simple algebra to chemistry.

As for the problems in our paper, it was not our intention that students be given the over-all equilibrium constant expressions but rather that they work out these relationships for themselves using the simple procedure outlined in our paper. Our main interest was to show that many different problems occur, whether they be real or academic, in which this procedure may be useful. The several specific criticisms may now be considered in order.

Problem 1. We did fail to insert, after "NaHD," the qualifying phrase, "in which HD^- is weak or intermediate in strength both as an acid and a base." The meaning of these strength designations is given in reference (2) but may be reviewed here briefly.

Strength designation of conjugate acid	*Acidity scale* pKa	pKb	*Strength designation of conjugate base*
Strong			Feeble
	2	12	
Intermediate			Weak
	7	7	
Weak			Intermediate
	12	2	
Feeble			Strong

The troublesome examples given by Professor Ricci were $NaHSO_4$ (HSO_4^- ion is a strong acid but a feeble base) and NaHS (HS^- is an intermediate base but a feeble acid). Insofar as the pH's of their solutions are concerned these substances may be treated adequately by considering the first merely as a monoprotic acid and the second merely as a monoprotic base. The reason for this is that the solvent, water, is both a feeble base and a feeble acid ($pKa_2 = 15.7$, $pKb_1 = 15.7$) of comparable or greater strength than bisulfate ion as a base or hydrosulfide ion as an acid.

Problem 2. The same qualification applies as in problem 1.

Problem 3. No comment.

Problem 7. At the beginning of the section in which this problem occurs the limitation to salts whose anions are weak or intermediate bases is expressly stated (the cations were neglected but should be non-acidic). In Professor Ricci's example, zinc sulfide, the anion is a strong base.

Problem 9. At the beginning of the section in which this problem occurs the term, "slightly soluble salt" appears. This implies a limit of applicability.

Problem 11. The section in which this problem appears begins: "If two slightly soluble salts . . . are in equilibrium with a solution."

Problem 13. This should read: "At what pH will zinc sulfide dissolve in saturated hydrogen sulfide solution (1 atm.) to form a 0.1 *M* Zn^{++} solution?"

Problem 14. The solution to this problem indicates that no material change in the concentration of sodium hydroxide occurs due to its reaction with zinc hydroxide.

DAVID DAVIDSON

BROOKLYN COLLEGE
BROOKLYN, NEW YORK

• INTRODUCTION TO PHYSICAL CHEMISTRY

Alexander Findlay, **Emeritus Professor of Chemistry, University of Aberdeen. Third edition. Revised by *H. W. Melville, F.R.S.,* Mason Professor of Chemistry, University of Birmingham. Longmans, Green and Co., London and New York, 1953. vii + 592 pp. 155 figs. 13.5 × 21.5 cm. $5.50.**

ALTHOUGH this is the third edition of this well-known textbook, it has not previously been reviewed in THIS JOURNAL.

The arrangement of topics is conventional, except that the discussion of thermodynamics comes rather late. This introduces a difficulty, since the treatment of solutions uses some of the equations subsequently derived in the chapters on thermodynamics; the difficulty would not be serious if there were sufficient cross references within the book,but equations are not numbered, and such expressions as "it has already been pointed out that . . .," or "we shall learn later that . . .," occur frequently, and the reader has to hunt diligently to discover where. To add to the confusion, where cross references are given, they are sometimes in error. For example: On page 94 we read, "Reference has already been made (p. 93) to the transpiration method of determining vapour pressures . . ."; this method is not given on page 93; it is discussed in another context more than 100 pages further on. On page 203 a reference is given to page 46; it should be page 41. On page 221, reference is made to chapter XIX; it should be chapter XVIII. As nearly as can be judged, these errors are due to carelessness in the revision; however they arise they make serious study difficult.

The aspect in which this text differs most markedly from many others is the emphasis given to the history of physical chemistry. The historical approach has certain advantages as well as disadvantages. Historical emphasis helps the student to see physical chemistry as a constantly developing body of knowledge, and to avoid the impression, so easily obtained, that our present ideas are necessarily and finally correct; the student who studies this book will see clearly that he is in midstream in an ongoing process.

On the other hand, there are certain hazards to the historical method which this text does not altogether avoid. The historical approach sometimes causes the student to learn something wrong, which he finds difficult to unlearn; or it may lead him to a subtly false impression, which he never consciously recognizes as false. An example of this is the misconception regarding the nature of solutions which was introduced by van't Hoff's interpretation of osmotic pressure as being due to bombardments by solute particles, and which emphasis on van't Hoff's work has helped to perpetuate. Furthermore, the student will probably gain the impression that there is something more fundamental about osmotic pressure than about the other properties of solutions; even electromotive force equations are derived from osmotic pressure relationships (page 374).

The first edition of this text, published in 1933, was reasonably modern and up to date in most respects, but subsequent revisions have not kept up with the times. The chapter entitled The Law of Mass Action Applied to Solutions of Electrolytes was well done in 1933, with keen insight into changing points of view—and changes were rapid at that time. But now, 20 years later, much progress has been made, perhaps more in ways of clarifying ideas —*i. e.*, in teaching methods—than in the ideas themselves, yet this chapter is almost unchanged. In the chapter on Behaviour of Electrolytes especially there are out-dated interpretations which should have been corrected by this time; for example (page 224), in the electrolysis of aqueous sodium chloride solutions, sodium ions "on being discharged, give rise to sodium which reacts with water with production of hydrogen," or (page 236) "The molecules of sodium chloride, NaCl, consist of sodium ions and chlorine ions in the form of electrically neutral 'doublets,' . . ."

Much of the third edition is identical with the first, but some changes have been made. A chapter entitled Molecular Dimensions and Configurations has been added; it is too brief and superficial to be of much value. Three chapters, Velocity of Chemical Reaction, Catalysis, and Photochemistry, which were scattered through the text in the first edition have been brought together and completely rewritten as a single chapter entitled The Mechanism of Chemical Reactions and Velocity of Chemical Change. Logically, this is a great improvement; unfortunately, the new chapter is somewhat disjointed, not well integrated with the rest of the text, and marred by occasional careless misstatements. The title of the chapter on colloids has been changed to Interfacial and Related Phenomena; the chapter has been partly rewritten, and new material on high polymers has been added. This chapter and that on adsorption have been interchanged in order, and the latter chapter also has been largely rewritten; again, the revision is marred by occasional mistakes.

Among the best features of the book are excellent and rather detailed descriptions, often including diagrams of the apparatus, of many of the "classical" experiments in physical chemistry. Many of the explanations of difficult points are done with keen insight into the difficulties which students are likely to encounter. Examples worked out in the text add greatly to its value, and an adequate number of problems and exercises are given in the appendix, together with answers to some of them.

WILLIAM E. CADBURY, JR.

HAVERFORD COLLEGE
HAVERFORD, PENNSYLVANIA

• INORGANIC CHEMISTRY: A TEXT-BOOK FOR ADVANCED STUDENTS

E. de Barry Barnett, **formerly head of the Chemistry Department, Sir John Cass Technical Institute, London, and *C. L. Wilson,* Reader in Analytical Chemistry, The Queen's University, Belfast. Longmans, Green and Co., London and New York, 1953. xiv + 512 pp. 27 figs. 12 tables. 16.5 × 25.5 cm. $7.**

AS INDICATED in the preface to this volume, the purpose of the book is to provide a text suitable for students "reading for a university degree or similar professional qualification," and it assumes a knowledge of inorganic chemistry covered in the usual intermediate course, as well as a familiarity with the essential principles of physical chemistry.

The plan of the book resembles in a general way that of Therald Moeller's "Inorganic Chemistry" (John Wiley & Sons, Inc., New York, 1952), in that the first part of the volume—seven chapters of a total of 27—deals with the more theoretical aspects of the subject, whereas the later chapters deal with the chemistry of the individual elements considered according to their position in the periodic system. A preliminary section on inorganic nomenclature is followed by a historical introduction (with special reference to the development of the periodic classification of the elements); chapters on the determination of atomic weights; on natural radioactivity; on the artificial breakdown of atoms; on isotopes and isobars; on the structure of the outer sphere of the atom; and on stereochemistry and crystal chemistry.

A chapter on the isolation of the elements precedes the discussion of the inert gases and of hydrogen. There follow chapters

on the elements of the A-subgroups, Group VIII, and the B-subgroups, ending with the halogens. A table of the electronic configuration of the elements is given as an appendix.

The authors remark that they have avoided giving technical or engineering details of chemical or metallurgical operations, "since such detail is chemical engineering rather than chemistry." References to the original literature are given only very sparingly, and then only to more recent work. In the reviewer's opinion, this omission deprives the book of possible value as a source book for further study on numerous topics which are treated only very briefly. An exception in this regard is in the case of the reports on German chemical industry, supplied by the Field Information Agency (Technical)—the so-called F.I.A.T. reports—shortly after World War II. Full references are given to these reports.

Doubtless in an attempt to reduce the size and cost of the work, the typography adopted in this volume gives the impression of a rather crowded format, and the close spacing of the lines results in a loss of comfort in reading, especially if lengthy passages are to be covered. The saving of space, furthermore, is to a certain degree canceled by the use of unnecessarily large figures or diagrams which appear in a number of places. For example, Fig. 26.3, page 428, occupies a full page, and Figs. 26.4 and 26.5 together fill page 436. Other figures, such as Figs. 10.2 and 10.3, 23.2, 26.2, 27.1, and a number of the diagrams of crystal structure, such as Fig. 15.1*a* and the figures on pages 84–91, are all presented on a scale larger than seems necessary.

There is evidence of the exercise of care to bring the subject matter up to date throughout the book; and comparatively few typographical errors were noted.

On the whole, this work is to be welcomed as another attempt to fill a long-felt want in chemical literature—a survey of inorganic chemistry at a level suitable for senior or graduate students, and with emphasis upon modern developments in this field.

WALTER C. SCHUMB
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

• COLLEGE CHEMISTRY: A SYSTEMATIC APPROACH

Harry H. Sisler, **The Ohio State University,** ***Calvin A. Vander Werf*** **and** ***Arthur W. Davidson,*** **both of The University of Kansas. The Macmillan Co., New York, 1953. xi + 623 pp. 180 figs. 105 tables. 15.5 × 23.5 cm. $5.25.**

THIS book is a "shorter, more compact" text than the authors' "General Chemistry: A Systematic Approach" and yet retains all the good features of the other text. It may be used equally well for students who have had no chemistry and for those who have had chemistry in high school. The development is so clear as to be readily grasped by the former while the approach is challenging and stimulating for the latter. The book is furthermore a sound and adequate introductory course for science students.

The core of the book seems to be "the unfolding of the chemist's present concept of the structure of matter. . . .certainly one of the greatest triumphs of the human intellect." The basis of principles on structure, the correlation of structure with position in the periodic table, and the consequent predictability of properties and behavior are well presented. The introductory paragraphs to the various chapters make excellent transitions which produce an integrated whole that is quite satisfying.

The applications of the principles are well developed throughout the book and quantitative relations are explained clearly and simply. The diagrams, illustrations, and tables are excellent and different in that they teach as well as illustrate. The chemistry of the atomic nucleus, which includes radioactivity, incontrovertibility of mass and energy, artificial nuclear transformations, atomic energy and explosives, is fittingly placed in the last chapter. Ordinarily in most first-year texts this material, in the opinion of this reviewer, interrupts the unity of the presentation of chemical properties and chemical change.

Those who feel they should include introductory qualitative analysis in the first year of chemistry will not find qualitative tests explained. However, the significance and applicability of analytical principles are emphasized in the chapters on solutions, acids and bases, and equilibrium. Organic chemistry and colloids are adequately treated.

For the past three years this reviewer has been looking for a text such as this which certainly gives the desired background for physical chemistry.

SISTER M. CONSILIA HANNAN
SAINT JOSEPH COLLEGE
WEST HARTFORD, CONNECTICUT

• THE CHARACTERIZATION OF ORGANIC COMPOUNDS

Samuel M. McElvain, **Professor of Chemistry, University of Wisconsin. Revised edition. The Macmillan Co., New York, 1953. ix + 303 pp. 15 figs. 40 tables. 14.5 × 22 cm. $4.50.**

THIS revised edition represents a refinement of an excellent text first published eight years ago. No changes have been made in order or form, but where necessary more modern electronic explanations have been incorporated and new or more workable laboratory directions substituted. This book is still admirably suited to class use since techniques are well explained and each reaction is so clearly discussed, both from the practical and theoretical point of view, that little remains to be covered in lecture.

The introductory chapters on general procedure, determination of physical constants, determination of the elements, solubility of organic compounds, discussion of the class reactions, and separation of mixtures have remained almost unchanged. The one improvement has been more up-to-date explanations of certain phenomena such as hydrogen bonds, the reactions of alkyl halides, the solubility of amines and the colors produced by meta dinitro compounds with base and acetone. Two of the three sets of questions and problems are entirely new.

More changes appear in the two chapters giving actual directions for laboratory work. A few of the class reactions have been rewritten. For example, more reliable directions are given for the iodoform test, phosphorus pentachloride has been substituted for phosphorus oxychloride in the preparation of sulfonyl chlorides, and iron is used in place of tin in the reduction of the nitro group. A few reactions have been added, such as the lithium aluminum hydride test for the nitro group, the use of ferric chloride in anhydrous solvents in the phenol test, and methods for hydrolysis of sterically hindered compounds.

The long chapter on the selection and preparation of derivatives has been modified the most. In addition to deleting less applicable derivatives and making several additions to the tables of melting points of the common derivatives, the author has included lists of and references to less common derivatives, inserted a new section on amino acids, and almost completely revised the discussion of phenols, hydrocarbons, and sulfonic acids and their derivatives. Also the refractive indexes of esters have been tabulated. New laboratory directions are given for the preparation of 3-nitrophthalates of alcohols, phenylureas from amines, three derivatives directly from esters, 3,5-dinitrobenzoates and N-aryl carbamates from phenols, pyrazoles and pyrazolones from enols, and S-benzylthiouronium salts and *p*-toluidine salts from sulfonic acids. In addition newly announced derivatives of both aliphatic and aromatic hydrocarbons are discussed and references to the original literature given.

The reviewer feels that this new edition, still only 300 pages in length, is a necessary addition to an organic qualitative laboratory. Its main drawback is a paucity of tests for particular functions: for example, the benzenoid structure test, the hydroxamate test, the various tests for amines and phenols, and the modified Beilstein test.

MARGARET K. SEIKEL
WELLESLEY COLLEGE
WELLESLEY, MASSACHUSETTS

• THE COMPOSITION AND ASSAYING OF MINERALS

John Stewart-Remington and _Wilfrid Francis_. William Clowes and Sons, Ltd., London; Philosophical Library, Inc., New York, 1953. viii + 127 pp. 14.5 × 22.5 cm. $5.50.

This thin volume "relates primarily to the chemical composition of minerals, with the object of providing a handy guide to their qualitative and quantitative examination that is suitable for use by mineralogists, metallurgists, geologists, chemists in mine laboratories, and students in schools, technical colleges, and universities." The book is divided into five parts: I, Qualitative Examination, 9 pages; II, Metallic Minerals, 89 pages; III, Typical Assays of Ores, 9 pages; IV, Non-Metallic Minerals, 11 pages; V, General Chemical and Mathematical Data, 9 pages. It also contains a folded table of a general qualitative analysis scheme for metals. There is no index.

The emphasis is on the metals and for each is given short descriptions of some of the minerals, several qualitative tests, and one or more procedures for quantitative assay. Most of the analyses are by wet assay methods, although a few dry assays are described. Spot tests and spectrographic methods are not described. Chemical equations for the reactions involved in analyses are given.

The treatment of minerals is of uneven quality and contains a number of mistakes. Microcline, $KAlSi_3O_8$, is referred to as a "tricalcium potash felspar" (page 110). Perhaps they meant triclinic. Amethyst is erroneously assigned to corundum on page 51 and correctly to quartz on page 108. Rhodonite is listed as a manganese mineral and rhodochrosite is not listed. Most of the mineral localities are British, as is proper for a British book, but several of those given for the United States are relatively unimportant. Several misspellings of mineral names were noted, as for example "desclorzite" for descloizite (page 76); "wartzite" for wurtzite (page 62), and "henlandite" for heulandite (page 112). The compositions of silicate minerals in the table on pages 113, 114 are too much simplified.

The chief value of the book lies in the compact and clear statement of procedures and analytical schemes.

ALONZO W. QUINN

Brown University
Providence, Rhode Island

• GMELINS HANDBUCH DER ANORGANISCHEN CHEMIE. SYSTEM 41: TITAN

Edited by _Eric Pietsch_. Eighth edition. Verlag Chemie, GMBH, Weinheim, Germany, 1951. xxii + 481 pp. 100 figs. 17.5 × 25.5 cm. $27.20. (Available through Walter J. Johnson, Inc., 125 E. 23rd St., New York 10, N. Y.)

It is inevitable that the new issue of Gmelins Handbuch on titanium should be compared with Jelks Barksdale's "Titanium"[1] which appeared two years ago. In the period between these two publications, titanium as a metal has come of age. While the basic technology for the production of titanium had been worked out, commercial production had hardly begun when Barksdale completed his manuscript. The Gmelin treatise, which uses Barksdale's book as one of its general references, has brought technological developments of the metal up to 1950.

The differences between the two books are, however, more than two years between dates of publication. These two treatments reflect entirely different concepts of technical book production. One is a commercial venture supported by the author, who has put countless hours into the preparation of the manuscript, and by the publisher, who has gambled a considerable sum of money to put it on the market. The other is a typical German handbook, compiled by a competent staff which works for a salary, supported by the chemical industry both here and abroad, and sponsored by a famous institute. The Barksdale book (besides being in English) is a readable, informative, and competent treatment of the element and its compounds, but the Gmelin is a far better and more definitive reference book. Barksdale has numerous references to the literature that are conveniently collected in an appendix and is supplied with a helpful index. The Gmelin has even more numerous references, but they are interposed into the sentences themselves, which makes for harder reading, and is supplied with only a table of contents in lieu of an index.

It may be harder to dig information out of the Gmelin, but it contains more. For example, barium titanate is now recognized as a useful piezoelectric material. Gmelin has devoted 20 pages of fine print to the compound and its behavior in five crystalline modifications, of which about two pages are concerned with its piezoelectric behavior. Barksdale has about five pages on this compound, scattered throughout the book, and does not mention the piezoelectric phenomenon. The situation is similar with other somewhat less familiar, albeit simple titanium compounds, such as the monoxide (TiO) and the nitride (TiN). On the subject of cutting tools and other products based upon alloys of titanium carbide (TiC), on titanium dioxide (TiO_2) pigment, and on other products which have important commercial applications, on the other hand, Barksdale has excellent chapters. These comparisons are not intended to be disparaging, but to emphasize the demands made upon an author who is putting out a book that must be a commercial success, in comparison with those placed upon an institute committee to publishing all the known information about one of the elements and its compounds. This emphasizes the need in the United States for an institute (possibly the National Science Foundation?) which can sponsor handbooks comparable to Gmelin and Beilstein.

The excellence of this volume on titanium is in keeping with the high standards set by the Gmelin Institute. Every phase of titanium chemistry and technology is considered, with the usual prolific references to the literature. Obsolete information has been weeded out and the literature has been carefully reviewed through 1949. It is obviously an essential addition to any library which purports to cover the field of chemistry.

LAURENCE S. FOSTER

Belmont, Massachusetts

[1] Reviewed in this Journal, **27**, 290 (1949).

• ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY. VOLUME X: PENTACENE TO POLYMETHINE DYES

Edited by _Raymond E. Kirk_ and _Donald F. Othmer_, Professors and Heads, Departments of Chemistry and Chemical Engineering, respectively, at the Polytechnic Institute of Brooklyn. Assistant Editors, _Janet D. Scott_ and _Anthony Standen_. The Interscience Encyclopedia, Inc., New York, 1953. xvi + 976 pp. 19 × 27 cm. $25.

In 1947 Volume I of E.C.T. appeared with the promise that two volumes would be published annually until the set of ten volumes was complete. The editors have labored nobly to try to maintain this publication schedule, but the amount of excellent material just could not be condensed to ten volumes. Fortunately, they believed it better to increase the number of volumes than to condense and eliminate the encyclopedia material. This policy has extended the time necessary for completion of the set, but has increased appreciably the value of E.C.T.

Not since the letter "C" has so much appeared under one letter heading. The P's carry a wealth of industrial chemical items running from perfumes (33 pages) to polymers (15 pages). Between these two entries are found sections on petroleum (139 pages), phenolic resins and plastics (35), phosgene and derivatives (11), phosphoric acids and phosphates (40), phosphorus and alloys (20), pigments (83), plasticizers (32), plastics (21), plywood (11), economic poisons (7), polishing materials (15), polyamides (22), and polyethylene (19).

It might appear that the sections on plastics (21) and polymers (15) are rather brief for these important subjects. "Plastics" covers briefly the entire field and gives cross references to the particular items which deal specifically with a special item, as phenolic resins and plastics (35). "Polymers" covers the theory and

classification of high polymers and the determination of physical-chemical properties. "Polyamides" discusses in some detail the production of 66-nylon and other salts of this type. "Polyesters" merely refers to cross-references under five other headings.

The petroleum industry is the giant in this volume, with cross-references to many petroleum products discussed individually. The composition and origin of petroleum are discussed extensively. A lengthy table gives compositions and properties of many petroleum products. Separate sections are devoted to petroleum chemicals and to petroleum waxes. This section will be used frequently for its authoritative material on processes and products.

The inorganic chemist will find much of importance to him. Sections on peroxides and peroxy compounds (20), phosphorus and its compounds (52), phosphoric acids and phosphates (40), and the platinum group metals (41). The analytical chemist will find sections on polarimetry (8) and polarography (14).

The organic chemist is interested in the sections on perfumes (33), peroxides and peroxy-compounds (30), pharmaceuticals (33), phenol and phenols (43), phenolic aldehydes and ethers (15), phosphorus compounds (16), phthalic acids (23), as well as many of the organic industrial items. The physical chemist will find sections on the phase rule (13), photochemistry (9) and photoelectric cells (23). The chemical engineer will refer to sections on pilot plants (15), plant layout (7) and location (10), as well as pipes and valves (13).

The section on photography (42) will be read with interest by those amateur photographers who desire to know more about the scientific and technical background of film manufacture, development, and the photographic process in general.

All of us are pleased that Volume X is not the end of E.C.T., but we are looking forward to the completion of this valuable reference set. It is hoped that extensions and revisions of the original material are planned as a continuing program to better our chemical reference material.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● WHAT IS SCIENCE?

Norman Campbell, **physicist. Dover Publications, Inc., New York, 1952. (Reprint of 1921 publication.) 192 pp. 13.5 × 20.5 cm. Cloth $2.50, paper $1.25.**

● MAN, THE CHEMICAL MACHINE

Ernest Borek, **New York City College, and Research Associate in Biological Chemistry, College of Physicians and Surgeons, Columbia University. Columbia University Press, New York, 1952. xiv + 219 pp. 14 × 22.5 cm. $3.**

THERE is no dearth of books intended to explain to the high-school student or college freshman the nature of science or of some particular science, hoping to attract the student to the science by showing him what to expect from it. Some are as fanciful as the Sunday supplement or as trivial as some advertising copy—others are on a more restrained and adult level. These two books are of the latter type. The first attempts to answer the question "What is Science?" in part by asking and answering such other questions as "What is a 'law' of science?" "How are laws discovered, explained, used?" "What is a theory?" "What is measurement?" Its thesis is that the fundamental aim of science is to satisfy our purely intellectual desires. "It has applications to practical life, only because it is true; and its truth arises directly and immediately from its success as an instrument of intellectual satisfaction" (page 158). The same thread runs through Professor Borek's book, but is embellished by many applications of biochemistry. The author refers to two stages in the development of biochemistry. The first stage is a descriptive biochemistry in which the principal task is to identify the molecules taking part in biochemical reactions. The second stage requires greater rigor, skill, and ingenuity and is concerned with discovering the relationships between molecular structure and cellular function. If the first stage is a kind of "molecular anatomy" then the second is "molecular physiology." Although this book contains no chemical formulas, the author somehow convinces the reader that the future of biochemistry lies in "molecular physiology."

In the first chapter is an account of Wöhler's synthesis of urea, its historical background and its significance in initiating the science of biochemistry. Later chapters deal with enzymes, vitamins, sugars, the use of isotopic tracers, amino acids and proteins, the blood, the defense of cells against toxic substances and bacteria, genes and the chemical basis of heredity, and the chemistry of nerve impulses. In a clear and easily followed style the author portrays the environment of biochemical investigation through an exciting and stimulating account of biochemical discoveries and their relation to each other.

Of the two books, Mr. Campbell's philosophical essay on the nature of science is the more mature and thought-provoking. Because of its comparative abstractness it is perhaps less suitable for beginners in science and of greater value in clarifying the thinking of those who already have some experience with one or several of the sciences.

WALTER B. KEIGHTON

SWARTHMORE COLLEGE
SWARTHMORE, PENNSYLVANIA

● KINETICS AND MECHANISM

Arthur A. Frost **and** ***Ralph G. Pearson,*** **Associate Professors of Chemistry, Northwestern University. John Wiley & Sons, Inc., New York, 1953. vii + 343 pp. 51 figs. 38 tables. 15 × 23.5 cm. $6.**

PROBABLY no branch of chemistry holds more industrial and scientific interest today than does chemical kinetics, the subject of this book. The conception of the equilibrium concentration of activated complexes crossing the barrier toward products (aside from the transmission coefficient effect) puts all of the methods of thermodynamics at our disposal. Such considerations are a central theme in the presentation. Although, in principle, the deduction of mechanism is possible from theory, in fact, it is usually arrived at only after much careful consideration of experiment. This procedure is well illustrated here. Enough experimental facts are usually given so that one gets a good picture of the status of the particular reaction under consideration. The book is written judiciously with interesting new material. Such a treatment of chemical kinetics is a welcome addition to student, teacher, and research worker alike.

HENRY EYRING

UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH

● THE BILE PIGMENTS

C. H. Gray, **Professor of Chemical Pathology, University of London. Methuen & Co., Ltd., London; John Wiley & Sons, Inc., New York, 1953. xv + 142 pp. 26 figs. 11 × 17 cm. $1.75.**

"THE Bile Pigments" is another volume of Methuen's monographs on biochemical subjects which measures up to the high standard set in earlier members of this series. These monographs demonstrate that it is possible to publish an adequate discussion of a biochemical topic in book form and at a cost which is not prohibitive to the average reader. In late years many fine scientific books, because of the expense involved, have been beyond the reach of many people who would like to own them.

In the early chapters of the present volume the structure of bilirubin, biliverdin, urobilin, mesobilirubin, and other bile pigment derivatives are treated in detail. The brilliant synthetic work of Hans Fischer and his associates in Munich, to whom we are indebted for much of our knowledge of the chemistry of bile

pigments, is carefully reviewed. The reactions of the bile pigments are discussed, especially the diazo reaction which is involved in the widely used van den Bergh test in jaundice.

With this background, the author turns to a consideration of the catabolism of hemoglobin and the somewhat controversial subject of the mechanism of bile pigment formation from hemoglobin. Among other topics treated in the later chapters are the origin of urobilin, stercobilin, and other pigments that may arise from bilirubin; the form in which bilirubin is carried in the blood during jaundice; and the significance of various derivatives, including dipyrryl compounds, that are occasionally found in the urine.

All of these topics are of immediate medical interest and frequently are reflections of aberrations in metabolism affecting the chemistry of the prosthetic group of hemoglobin. Correct interpretation of chemical tests for bile pigments and their derivatives is highly important as an aid in diagnosis of pathological conditions. Much of the later part of the book is concerned with such problems. The author remarks that " a stimulus is provided to the basic sciences by problems originating in the art and practice of medicine."

The reader will appreciate that many questions relating to the chemistry of the bile pigments and the origin and significance of related compounds remain to be answered. In the last chapter (Chapter XII), Gray has outlined some of the outstanding problems in this field. An appendix, which will be useful to workers in the laboratory, contains directions for the preparation of pure bile pigments, qualitative tests for bile pigments in urine, and methods for the determination of these pigments.

This small volume gives a summary of the present knowledge of the chemistry of the bile pigments and a critical presentation of their physiological significance in normal and pathological conditions. The author is an active research worker on bile pigment problems.

F. A. CAJORI

University of Colorado School of Medicine
Denver, Colorado

• CHEMISTRY OF FOOD AND NUTRITION

Henry C. Sherman, **Mitchill Professor Emeritus of Chemistry, Columbia University. Eighth edition. The Macmillan Co., New York, 1952. viii + 721 pp. 24 figs. 67 tables. 14.5 × 24.5 cm. $6.**

Dr. Sherman's book has served for decades in bringing up students of nutrition. Now appearing in an eighth edition, it represents, like its predecessors, an excellent contribution to the teaching of the elements of the field. The author states in his preface that "the present edition may be said to reflect forty years' teaching experience and resultant perennial revision of the rendering of this subject." The reader will find, despite the remarkable growth of nutritional science in the span of years covered by various editions of the text, that it still retains that readability and conciseness so essential for the student. Ample consideration is given the logical historical growth of the subject material, thus setting the book apart from a large number of current scientific texts which leave the impression that newer knowledge leaped forth full grown.

The chapter headings remain the same as in the previous seventh edition (1946) with the exception that three new ones have been added: Folic Acid, Vitamin B_{12}, and Citrovorum Factor; Trends in Food Consumption; and Improvement of Already-normal Nutrition. As each new edition finds new chapters added it can be hoped that a future edition will carry some chapter on the use and misuse of vitamin capsules, pills, and concentrates. Wise, authoritative council in this controversial matter would be most helpful for students of nutrition.

The appendix with its compilations on nutritional composition of food materials has been revised to include newer values from recent official and independent publications. Although the volume is designed as a textbook its value to all workers in nutrition is greatly broadened by the inclusion in each chapter of well-balanced bibliographies. These represent a gold mine of information on both old and new publications relating to the various topics.

ELIOT F. BEACH

Metropolitan Life Insurance Company
New York, New York

• PROGRESS IN THE CHEMISTRY OF FATS AND OTHER LIPIDS. VOLUME 1

Edited by *R. T. Holman,* University of Minnesota, *W. O. Lundberg,* University of Minnesota and *T. Malkin,* University of Bristol. Academic Press, Inc., New York, 1952. 186 pp. 25 figs. 16 × 24.5 cm. $7.

This is the first volume of a series to be published in which a critical survey of the rapidly expanding subject of the lipids will be presented. The contributions were intended originally for a new edition in English of Hepter-Schoenfeld's "Chemie und Technologie der Fette und Fettprodukte," a project that had to be abandoned due to the death of Dr. Schoenfeld.

The present volume contains five sections: "The molecular structure and polymorphism of fatty acids and their derivatives" by T. Malkin, "Sterols" by W. Bergmann, "Structure and properties of phosphatides" by P. Desnuelle, "Chromatography of fatty acids and related substrates" by R. T. Holman, and "Derivatives of fatty acids" by H. J. Harwood. In each of these sections the material has been presented in the form of a review including the historical development of the topic. This will appeal to the general reader interested in the work that has led to our present knowledge of various parts of lipid chemistry. However, the authors have not hesitated to discuss in detail highly technical phases of the subject which will make the book of particular value to the research worker and specialist in the lipid field.

The subject matter in the reviews conforms to the title of the book in that it is devoted strictly to the chemistry of the lipids. No attempt has been made to consider the biochemical aspects of the subject or the changes that fats and lipids undergo in living organisms. From the presentation of the material in the present volume, one can assume that the completed series will embrace an exhaustive and thorough treatment of the chemistry of this highly diversified and important class of natural products. The technological aspects of the subject will be considered in a forthcoming Progress Series.

Occasional typographical errors may be encountered (for example on page 145) but in general the book seems to be free of errors and the format is satisfactory.

F. A. CAJORI

University of Colorado School of Medicine
Denver, Colorado

• CRIME INVESTIGATION

Paul L. Kirk, **Professor of Biochemistry and Criminalistics, University of California, Berkeley, California. Interscience Publishers, Inc., New York, 1953. xxii + 784 pp. 16 × 23.5 cm. $10.**

This book consists of 57 chapters the first 35 of which are devoted to "Physical Evidence in General Criminal Investigations" followed by 22 devoted to "General Laboratory Operations." Each chapter is followed by a list of references which appear to be very well chosen and comprehensive. Without question this is the best book of its kind that has yet appeared. As stated by the author it is not intended as a guide for specialists but "rather with the needs of police investigators, general criminalists in the smaller police laboratories, and students of criminalistics and police science in mind." Specialists in the various fields, such as firearms investigators, document examiners, fingerprint experts, etc., may feel that the discussions in their particu-

lar fields are inadequate—but these individuals are not the ones for whom the book was written.

In addition to the technical discussions, which in general are excellent, there are chapters on the Relation of Probability to Physical Evidence, Training and Extent of Criminalistics, and The Expert Witness, all of which are interesting and valuable. The advice for the expert witness, if followed, will save him much embarrassment. To the list of subjects recommended as necessary training the reviewer would add a comprehensive course on applied microscopy, since the microscope is the most indispensable tool of the scientific crime investigator. The author does stress the importance of microscopy. His chapters on Equipment for Investigation and The Laboratory, Its Design and Operation will be very helpful to those who are starting new laboratories not only because of the valuable advice but also as substantial argument for adequate financial support for equipment and maintenance. State and muncipalities should not undertake to develop such laboratories unless they are prepared to give continued financial support, not only for equipment but, more important, for the payment of salaries which will attract and hold competent investigators.

The range of subjects covered is so large that even an enumeration of them is impractical here. The typography is excellent, with but few typographical errors, the illustrations are good, and the book is very readable. It can be read with profit and understanding by anyone who has a speaking acquaintance with the basic sciences. The reviewer finds little to criticize since he realizes that the book is for the uninitiated. He does, however, take exception to one statement where, in discussing the dermal nitrate test, the author ends a fairly good discussion of the earlier form of the test with the statement that, "It must be remembered that washing the hands before applying the paraffin gauntlet (*sic*) will effectively remove any test which would otherwise have been found." As a matter of fact repeated washings over a period of at least three weeks do not necessarily remove the particles of nitrate embedded in the skin. Furthermore, the test is made more reliable if the hands are washed before the paraffin is applied, since this will remove surface nitrates that may be present from other causes and whose presence might interfere with the true nitrate test which is concerned with particles that have become embedded in the skin because of the force of the explosion. However, among the thousands of true statements made in this excellent book at least one questionable one should be permitted.

J. HOWARD MATHEWS

University of Wisconsin
Madison, Wisconsin

● ORGANIC CHEMISTRY

Ray Q. Brewster, Professor of Chemistry, University of Kansas. Second edition. Prentice-Hall, Inc., New York, 1953. xii + 855 pp. 29 figs. 45 tables. 16 × 23.5 cm. $7.

This is a text for a full-year course. It treats aliphatic and aromatic compounds separately.

The first edition of Brewster's text gained wide recognition for its extensive reference to mechanisms in discussing fundamental reactions. It was a pioneer, entering an area in which there were few examples to follow, in which the pitfalls were not marked. The number of its followers is a tribute to the quality of the trail which it blazed.

Now, five years later, the pioneering stage has been passed. Now it is time, though we may be pleased by the general direction of the trail, to expect that some of its rough spots be smoothed, its hairpin turns be straightened, and its steep grades be moderated. Unfortunately Brewster offers, in this new edition, essentially the same pioneer trail.

More specifically, one would have wished that the somewhat awkward expositions of certain theoretical points had been replaced by smoother, less complicated discussions; indeed, some passages even tend to give erroneous impressions (for example, the discussion of nucleophilic displacements in alkyl halides, page 96, infers that all such reactions proceed by the S_N2 mechanism). Again, one would have wished that a better balance of emphasis between mechanisms and classical organic chemistry had been attained; for example, the importance of halogen addition to olefins in preparative and analytical work continues to be obscured by a long-winded discussion of the mechanism of such reactions. Further, one would have wished that modern concepts of reaction mechanisms had been introduced in certain chapters which are rather old-fashioned; for example, chapter 25 (Aromatic Nitro Compounds) fails to mention the well-established mechanisms of aromatic nitration and fails, in connection with reactions of chloronitrobenzenes with ammonia, sodium ethoxide, etc., to identify these reactants as *nucleophilic reagents*, though this term is used extensively earlier in the book.

A modern point of view is also lacking in parts of chapter 20 (Amino Acids and Proteins). The valuable and significant technique of enzymatic resolution of amino acids is not mentioned, modern methods for the synthesis of peptides do not appear, and the chapter fails to convey the enormous importance of proteins in life processes and the enormous difficulties of working with them.

Certain features of the new edition represent a distinct advance over the old. There are approximately twice as many problems at the end of each chapter. A chapter on organometallic compounds has been added. And in numerous places small changes in content or phrasing have been made.

No textbook is perfect. The teacher always finds it necessary to add here, to omit there. Those who found the first edition of Brewster's text convenient to teach from will like the new edition better. Those who tried the first edition and then looked elsewhere will probably not be attracted back by the second edition.

JOSEPH F. BUNNETT

University of North Carolina
Chapel Hill, North Carolina

● AN INTRODUCTION TO STATISTICS

Charles E. Clark, Associate Professor of Mathematics, Emory University. John Wiley & Sons, Inc., New York, 1953. x + 266 pp. Illustrated. 15 × 23.5 cm. $4.25.

This book is an elementary introduction to modern methods of statistical inference from samples, intended for workers in any field in which these methods may be applied. The author intends to presuppose a minimum of mathematical training and maturity, and in fact scrupulously minimizes even elementary algebraic manipulations, and touches no concept of calculus, or of analytics, except that understanding of Cartesian coordinates is assumed. The expository style is, however, conventionally mathematical and seems to this reviewer to lack a corresponding forbearance. Abundant use of letter symbols, references to previous equations, theorems, sections, and the like, may well give a mathematically inexperienced reader an unwarranted feeling of being in too deep water.

The subject matter of the book, however, is very well chosen and amply illustrated by numerical examples. There is a brief introductory discussion of permutations and combinations, and probability concepts. The main portion of the text treats *t*-tests, analysis of variance for single attribute, and chi-square tests, with clear emphasis on the underlying concepts of sampling distributions and confidence limits. The final chapter deals in a simple way with product-moment correlation and linear regression. Much problem material is included; the answers and solutions for odd-numbered exercises alone cover 34 pages. Six numerical tables make the book self-sufficient in this regard.

PHILIP RUDNICK

Scripps Institution of Oceanography
La Jolla, California

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A MANUAL for the ORGANIC CHEMISTRY LABORATORY

By Leigh C. Anderson, *and* the late Werner E. Bachmann, *both of the University of Michigan.* Here is a remarkable laboratory manual, designed to acquaint the beginning student with the specific experimental procedures necessary for a complete understanding of basic organic chemistry. The outgrowth of more than 20 years of pre-testing in undergraduate university classrooms, this manual has been checked and rechecked in actual laboratory application. It provides the theory and experimental data needed to perform more than 60 experiments with aliphatic and aromatic substances representative of the important classes of organic compounds. Flexibly written, it can be used with any text recommended for the lecture portion of the class. Each experiment included contains equations, directions, and discussions of the principles involved. General laboratory procedures are outlined, with reasons and precautions where necessary, so that the student will understand exactly what is being done.

1953. *164 pages.* *Probably $2.00*

Practical Methods of Temperature Measurement Stressed

TEMPERATURE MEASUREMENT IN ENGINEERING, Volume I

By H. Dean Baker, *Columbia University;* E. A. Ryder, *United Aircraft Corp.; and* N. H. Baker, *Columbia University.* Distinguished from all other books on the subject by its emphasis on a practical approach, this is the first volume of a two-part work. It provides, in convenient, non-mathematical form, all the engineering information needed to measure temperature. The authors include all the details essential to actual execution, avoiding unnecessary background theoretical material. They provide a list of possible techniques for each measurement problem, methods of analysis, and a survey of previous solutions. They then indicate what information is needed and offer a well-developed procedure of general application.

1953. *Approx. 178 pages.* *Probably $3.75*

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1953. *115 pages.* *$3.50.*

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MODERN ELECTROPLATING, Second Edition

Edited by Allen G. Gray, *Technical Editor, STEEL magazine;* M. L. Holt, *University of Wisconsin, Assistant Editor.* This book is the only source of up-to-date electroplating practice which emphasizes, in addition to the practical aspects, the basic theory as it is known today. Written by experts, it is a completely modernized revision of the Electrochemical Society's earlier *Modern Electroplating.* The purpose of this volume is to present the details of today's commercially available processes. It includes virtually *all* of the current practices; each completely and thoroughly described, even to analytical control of the solution—plus the theory underlying each.

In addition, the book presents a chapter on the uncommon metals and considers the problem of plating on aluminum and magnesium.

1953. *Approx. 563 pages.* *Probably $7.50*

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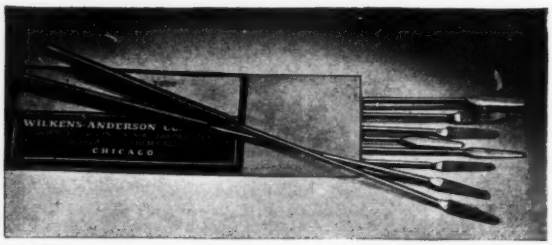

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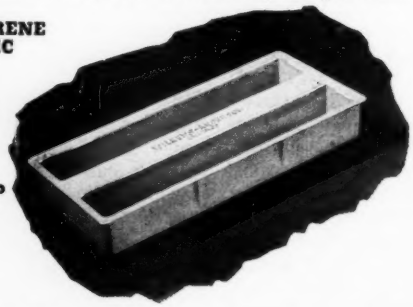

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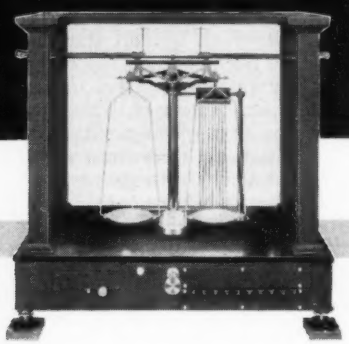

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Out of the Editor's Basket

New Infrared Microscope

A new microscope attachment for infrared spectrometers that gives infrared spectra of a single crystal, a single fiber and microscopic tissues, is now in production at The Perkin-Elmer Corp. With its use, infrared spectra have been obtained on single textile fibers less than seven ten-thousandths of an inch in diameter (17 microns). The synthetic fiber industry, as well as chemical and medical research, has wide application for such a device.

The microscope attaches directly to any Perkin-Elmer Single Beam Infrared Spectrometer. The optical system is made up entirely of reflecting elements, so that it is free of chromatic abberation. It is equipped with coarse and fine focusing adjustments for positioning the sample and with an adjustable diaphragm which restricts the field of view precisely to the area covered by the sample. The optical path may readily be flushed with dry nitrogen to reduce the carbon dioxide and water vapor absorption bands on the infrared spectra. The microscope is so designed that only radiation that has passed through the sample reaches the thermocouple. A complete spectrum can be recorded in about 20 minutes.

Complete details are available from The Perkin-Elmer Corp., Norwalk, Connecticut.

Chart of the Isotopes

A color-coded chart of the isotopes has just been published by Harshaw Scientific, Division of the Harshaw Chemical Co., Cleveland 4, Ohio. It was compiled and edited by John R. Bradford, Director, Radio Isotope Laboratory, Case Institute of Technology.

The chart is designed and lithographed in ten colors to make possible rapid identification of isotope half-life and nuclear stability.

More detailed information is available from Harshaw Scientific.

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The new Eberbach "Universal" Stirrer can be employed in many positions because of a double swivel clamp with an easy-operating hand wheel lock. Quiet-operating, with speeds up to 5000 r. p. m., this $^1/_{40}$ h.-p. stirrer offers maximum torque at various speeds by employing two output shafts, one being driven through a gear reducer. Ventilated rheostat housing also serves as a clamp to mount on the special support. This heavy duty support consists of a $^3/_4$-in. rod on a 13-lb.base designed so a 12-in. cylindrical container can be placed close to the rod; the base has four additional threaded holes for extra support rods. Complete information contained in bulletin 480 from Eberbach Corp., Ann Arbor, Michigan.

New Pipet

A new pipet with a built-in constriction designed to facilitate use of the conventional cotton plug for the protection of both laboratory workers and the solutions and cultures with which they work, has been developed by the Kimble Glass Co., a subsidiary of Owens-Illinois Glass Co.

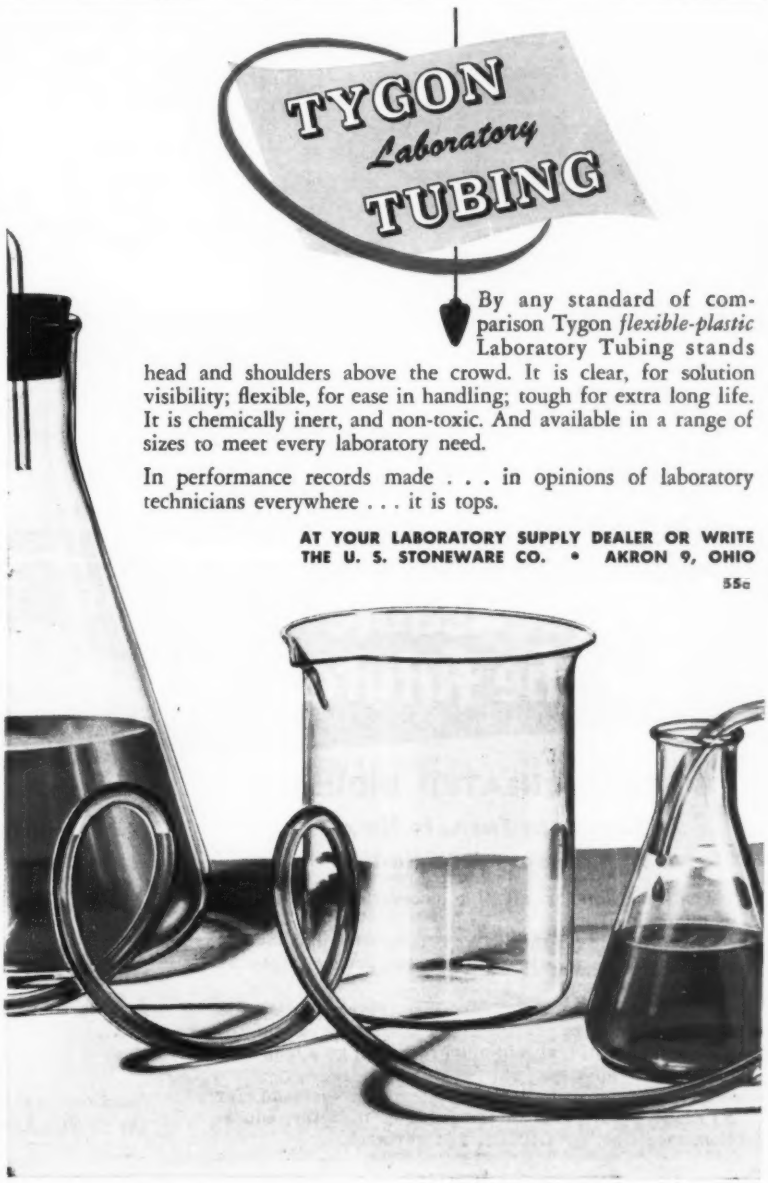
Based on a suggestion by Dr. H. Gilbert Crecelius, Director of Laboratories of the Arizona State Dept. of Health, the constriction is placed near the mouth-end of the pipet. Although large enough for easy cleaning, the constriction permits use of the cotton plug without risk of it slipping into the body of the pipet.

The cotton plug serves a dual purpose. It provides a safeguard for the laboratory worker pipeting solutions containing harmful bacteria. It also prevents contamination of solutions or cultures by bacteria from the breath of the operator.

The new pipets are now available in laboratory supply houses and compare in price to standard pipets.

Glass Metabolism Cages

Wakefield Industries, Inc., Skokie, Illinois, has announced a complete line of glass metabolism cages for use in the metabolic studies of carbon-14 labeled



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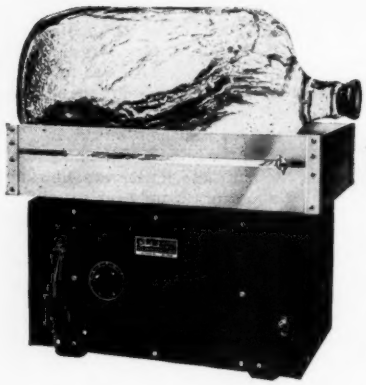

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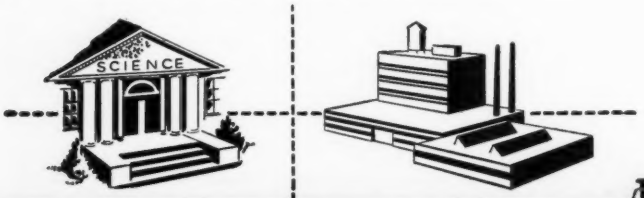

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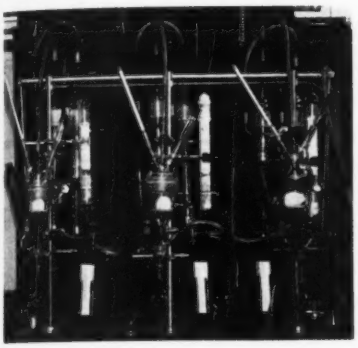

For further information, including drawings, write Dept. WPF-9, Wakefield Industries, Inc., Skokie, Illinois.

New Chemicals Available

● Bios Laboratories, Inc., 17 West 60th Street, New York 23, New York, announces the availability of the following new chemicals: 2,2′-Biquinoline (2,2′-Diquinolyl), M.W. 256.3; Bixin (Norbixin Methyl Ester), M.W. 394.5; Caffeic Acid (3,4-Dihydroxycinnamic Acid), M.W. 180.15; Cholesteryl Oleate, M.W. 651.1; Coumarone (Benzofuran), M. W. 118.1; 1,1′-Dianthrimide, M.W. 429.4; Isoascorbic Acid, d(-); M.W. 176.1; Purpurogallin (Pyrogalloquinone), M.W. 220.1; 2-Pyridoin (α-Hydroxy-β-Keto-Dipyridyl Ethane), M.W. 214.4; Xanthosine (Xanthine-9-Ribofuranoside), M.W. 284.3.

● Schwarz Laboratories, Inc., 230 Washington St., Mt. Vernon, New York, announce that they can now furnish any desired quantities of L-amino acids including L-Arginine, L-Aspartic Acid, L-Glutamic Acid, L-Histidine, L-Lysine, L-Phenylalanine, and L-Tyrosine uniformly labeled with C^{14}. The specific radioactivity for these amino acids is about 0.1 millicurie per millimole.

New Literature

● Laboratory Construction Co., 1115 Holmes St., Kansas City, Missouri, offers free a six-page bulletin featuring a pictorial tour of the new Department of Agriculture Laboratory, State of Colorado, at Denver. Illustrates latest design in specialized furniture and equipment for this type laboratory.

● A manual explaining the new Universal Balance has recently been published by the manufacturer, Voland & Sons, Inc., 32 Relyea Place, New Rochelle, New York.

This new instrument, which the manufacturer claims is a completely new concept in balances, is fully illustrated in the manual. Comprehensive diagrams and photographs describe the many unusual features of the Universal Balance, including the beam and projection systems, weigh operation, compensating stirrups.

● A new catalogue, No. 16, on Laboratory Equipment and Supplies is announced by The Denver Fire Clay Co., 2301 Blake St., Denver 2, Colorado. This 764-page book has specific value for any laboratory—industrial, clinical, research, educational, etc.

Lines of DFC manufactured products not properly included in a catalogue of Laboratory Equipment and Supplies—such as heat-treatment furnaces, industrial gas or oil burners, industrial furnaces, ceramic kilns, and metallurgical equipment—are cross-indexed to special bulletins on the respective products. This adds to the value of Catalogue No. 16 as a source reference.

Copies of Catalogue No. 16 may be obtained by request on your business or professional letterhead.

● A new 16-page catalogue which illustrates and describes in detail the JAco line of grating spectrographs is now available from Jarrell-Ash Co., Newtonville, Massachusetts.

Included in the publication is technical information on all standard JAco Spectrographs including the 3.4-meter, the 2.5-meter, and the 5.5-meter adjustable types and the 3.4-meter and 1.5-meter fixed position spectrographs. Other sections of the catalogue cover accessory equipment,

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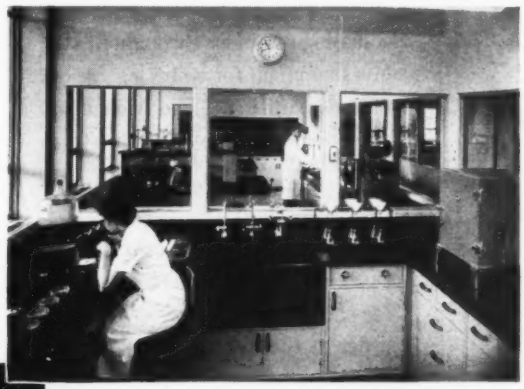

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information on the production of the diffraction gratings used in JAco Spectrographs, suggested spectrographic laboratory layouts, and a brief description of accessory and complimentary instruments which are manufactured by Jarrell-Ash.

A copy of Catalogue G2-53 is available by writing Richard Ashley, Vice-President, Jarrell-Ash Co., 26 Farwell St., Newtonville, Massachusetts.

● Complete information on the use of ash-free, dry-dispersed analytical filter pump as a filtration aid is now available from Carl Schleicher & Schuell Co., Keene, New Hampshire, manufacturers of analytical filter papers. Request Bulletin No. 68.

● A newly published 48-page Burrell Catalogue lists and describes equipment and accessories for gas analysts.

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● The growing importance of instrumentation to nearly every modern industry, large or small, is dramatized by actual case histories appearing in the latest *Beckman Bulletin*, house magazine of Beckman Instruments, Inc. Featured in this new issue is a colorful story of "seagoing" spectrophotometers and pH meters—utilized in far-flung expeditions by Scripps Institute of Oceanography. Copies of this informative 8-page magazine can be obtained from Beckman Instruments, Inc., South Pasadena 1, California, through requests for BB-11-36.

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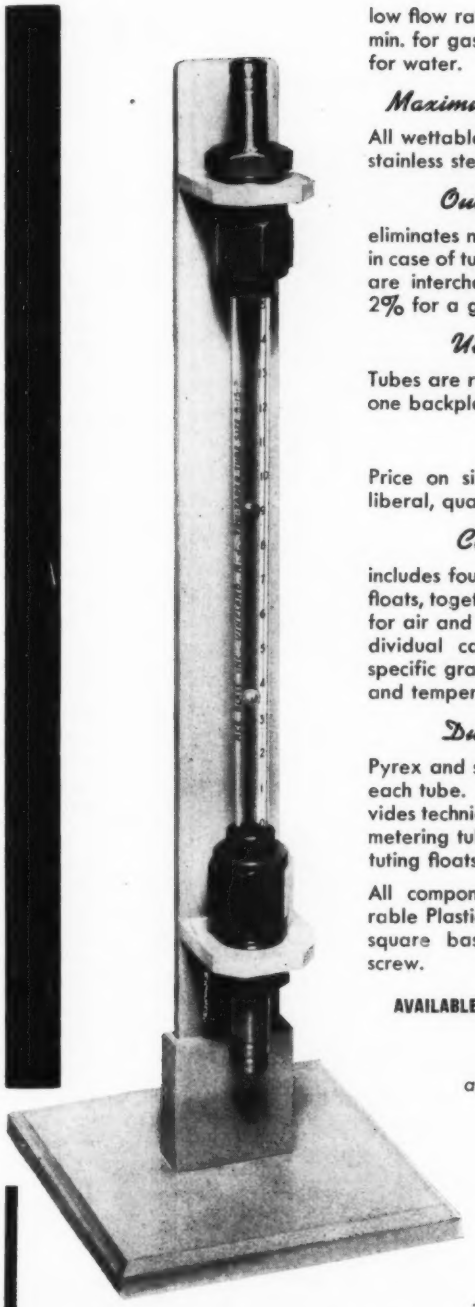

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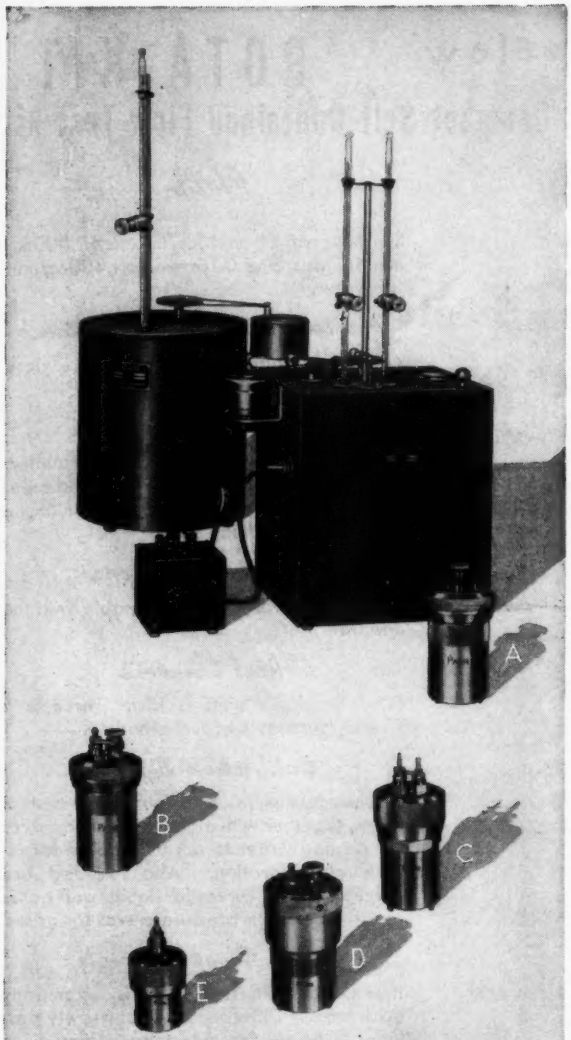

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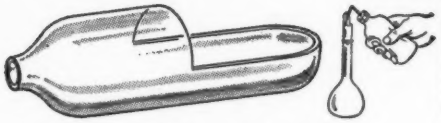

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References

(1) Ind. Eng. Chem. 25-653 (June, 1933)

(2) Ind. Eng. Chem. 25-1112 (Oct., 1933)

(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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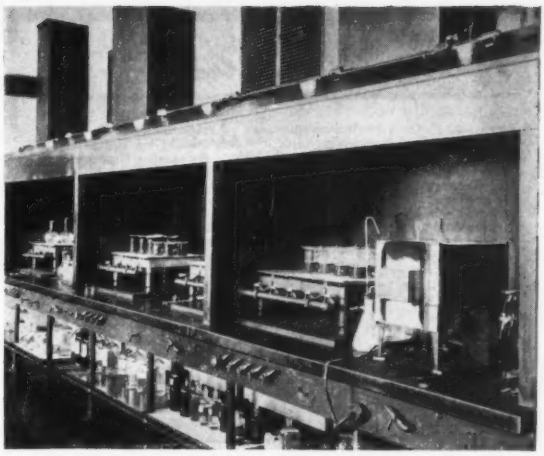

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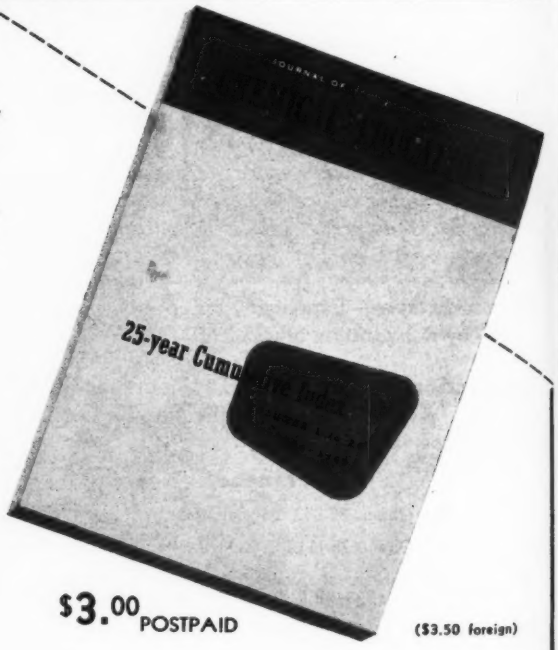

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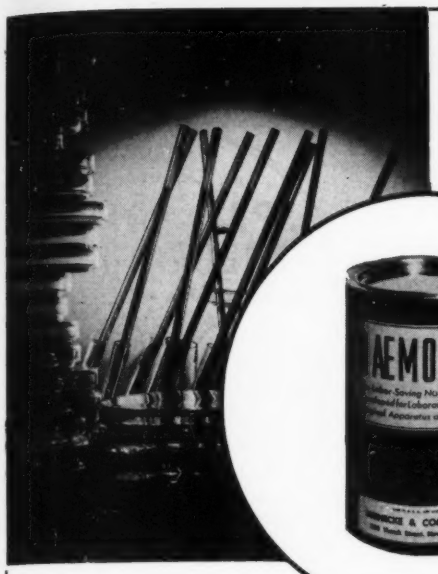

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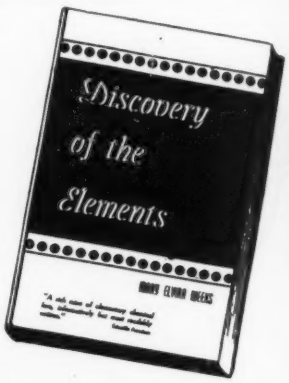

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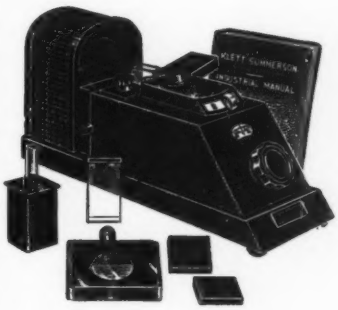

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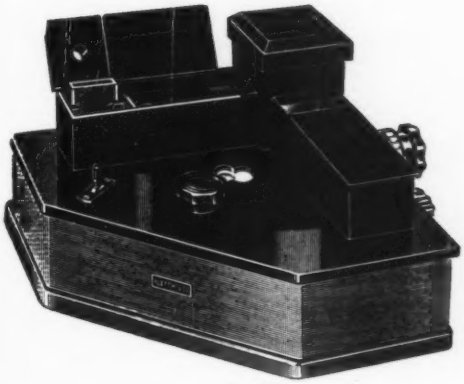

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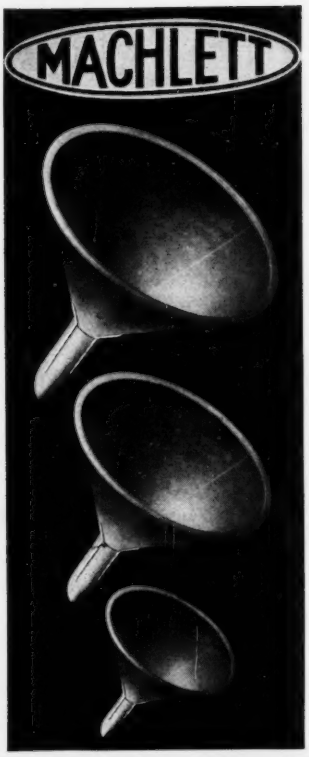

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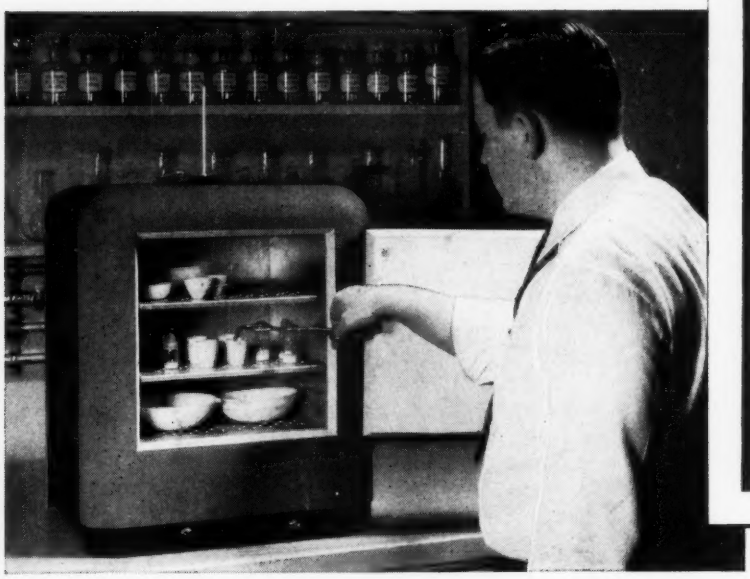

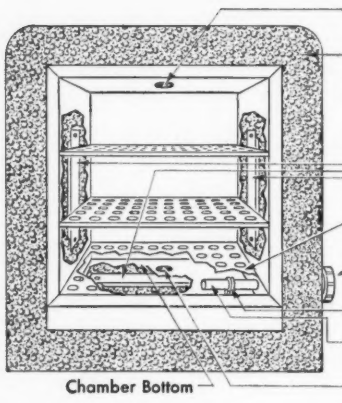

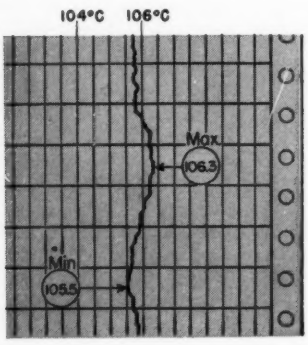

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